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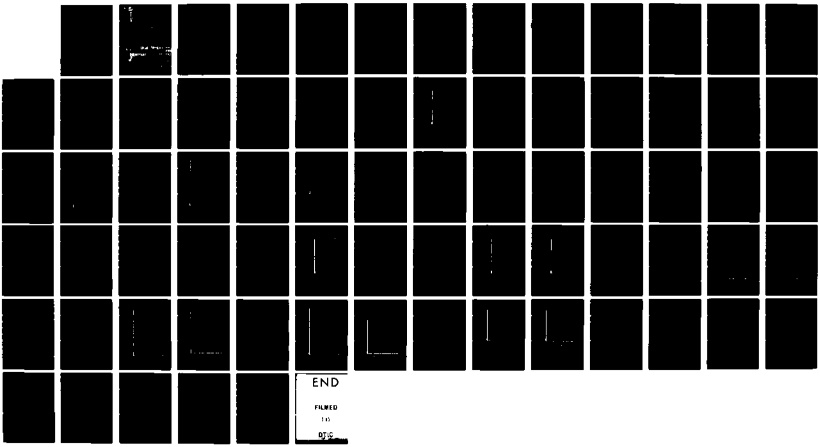

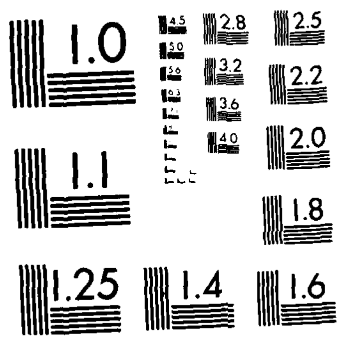

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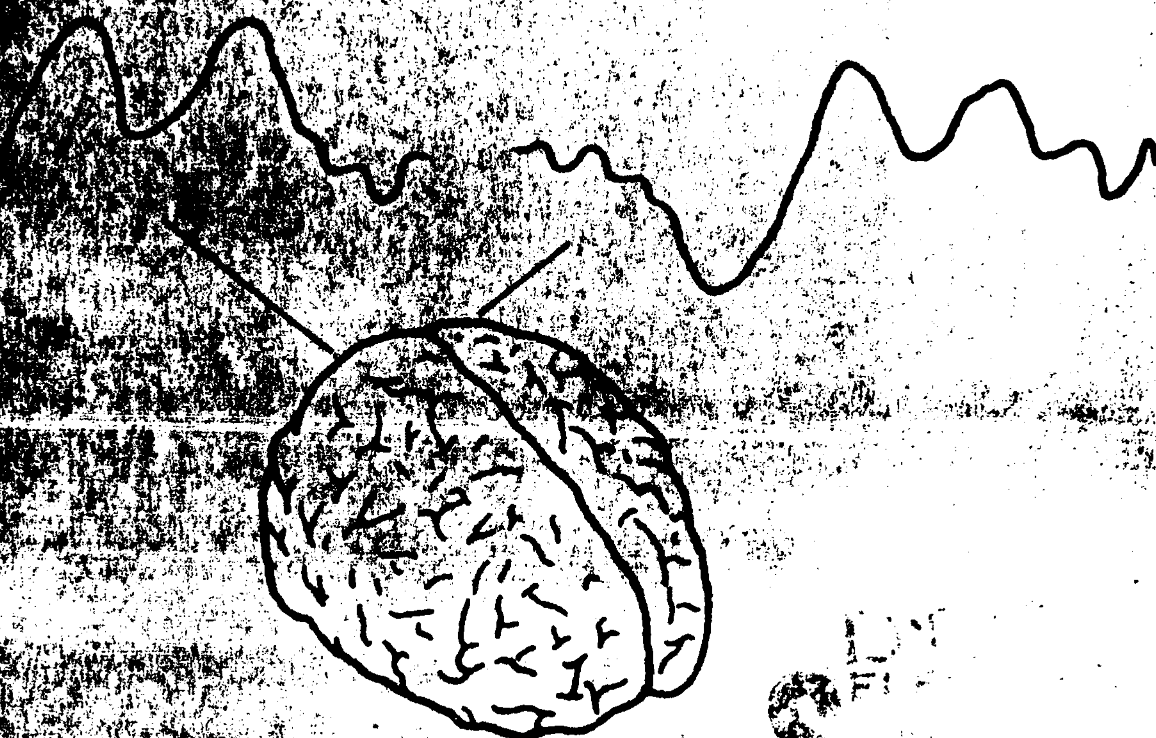

Brain Responses and Information Processing

Psychophysiology Laboratory
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This is the third annual report to originate from this laboratory. The research completed over the last 12 months has included studies concerned with evoked brain potentials and performance measures during perceptual discriminations. Experiment I examined the event related potential (ERP) during discriminations of line orientation in three visual fields. The main finding concerning discrimination performance confirmed the main hypothesis of the study. Namely, that right hemisphere discriminations (LVF) would be better

than left (RVF), but only for males. Another important finding was that, while the discrimination task invoked an expected P3 response, significantly larger P3 amplitudes were associated with the line orientation stimulus (i.e., 55° line) requiring a "YES" response. It was hypothesized that P3 amplitude reflects some implicit cognitive act which attributes greater importance or relevance to a stimulus which requires a positive response. A follow-up study was briefly described in which subjects will be required to say "YES" to the 50° line and "NO" to the 55° line, with the expectation that the P3 amplitude advantage would switch to the 50° line.

Experiment II concerned the discrimination of motion velocities and the relation of this process to ERPs. Our performance data indicated that left hemisphere discriminations (RVF) were superior to right (LVF). A separate analysis of male-female performance indicated that females contributed to this effect more than males. It was suggested that the sequential-temporal nature of the motion situation might make it a left hemisphere function. In addition, performance data for males indicated a left hemisphere decrement over time. It was proposed that a follow-up study be conducted to determine whether the observed decrement for males occurs over a longer time period. Finally, laterality effects were suggested for the P3 component since right hemisphere derived amplitudes for P3 were larger with the faster velocity.

BRAIN RESPONSES AND INFORMATION PROCESSING III: HEMISPHERIC ASYMMETRY IN EVENT RELATED POTENTIALS AND PERFORMANCE DURING DISCRIMINATION OF LINE ORIENTATION AND VELOCITY OF MOTION

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For:

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Third Annual Report

30 November 1982

Brain Responses and Information Processing III: Hemispheric Asymmetry in Event Related Potentials and Performance During Discrimination of Line Orientation and Velocity of Motion.

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and

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Abstract

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Introduction - Possible Applications of this Research to Air Force Problems

In last year's annual report we suggested some practical implications of our research findings. It was pointed out that Human Factors Engineers have done an admirable job in the improvement of display design. However, the belief was expressed that basic researchers could provide information with the potential to further enhance human performance.

It is our belief that monitoring event related brain potentials can assist equipment designers by providing information regarding the relative efficiency and involvement of right and left hemispheres of the brain in various perceptual and information processing activities. For example, if it is found that the right hemisphere processes certain types of display information better than the left, then that type of information should be selectively presented to the right hemisphere.

In the first study covered in this annual report evidence was found for more efficient processing of line orientation by the right hemisphere of male subjects. If this result is replicated it would suggest that when a choice must be made between placing different kinds of displays to the left or right of center then displays involving discrimination of orientation should be placed in the left visual field. That is, the information would be presented to the left of center since stimuli at that location project primarily to the right hemisphere.

Discrimination of motion velocity reported on in the second study indicated superior left hemisphere performance especially for females. If this is found to be a reliable effect then it could be a rationale for the placement of displays involving motion in the right visual field.

Experiment I - Discrimination of Line Orientations in Three Visual Fields and Associated Event-Related Brain Potentials

Introduction

Cerebral hemispheric asymmetry has been extensively studied under many different experimental situations over the last decade. Examples of some studies are those dealing with unilateral brain lesioned and commissurotomized patients (Sperry, 1974, 1982; Kinsbourne, 1978) and those using visual discrimination paradigms with normal subjects e.g., Umilta et al., 1973, 1974, 1978; Sasanuma & Kobayashi, 1978; Koss, 1981. The concept of hemispheric asymmetry that has been developed attributes analytic, mathematical, and language related functions to the left hemisphere, and synthetic, nonverbal, and visuo-spatial functions to the right (Gazzaniga, 1978).

There has also been work on the question of sex differences in hemispheric asymmetry. Harris (1978) suggests that the male brain is lateralized with respect to linguistic-visuo-spatial functions (i.e., left hemisphere - language; right hemisphere - visuo-spatial), while in females, both hemispheres equally participate in these same activities. This notion received support from several studies, some of which addressed developmental aspects of male-female cerebral lateralization (Molfese, 1973; Rudel et al., 1974; Wittelson, 1975) and others on adults using electrophysiological and perceptual measures (e.g., Rebert and Low, 1978; Sasanuma and Kobayashi, 1978). In the Sasanuma and

Kobayashi study, it was found that males showed a significant left visual field (LVF) superiority (right hemisphere) in a line orientation discrimination task, while females did not. Similarly, Koss (1981) had six male subjects discriminate two lines oriented 95° and 100° from horizontal, projected in left and right visual fields, and reported a LVF superiority.

A contrasting position on this question has been taken by Buffery and Grey (1972), who proposed that females are more lateralized along the linguistic-visuo-spatial dimension while males are more bilateralized. These authors cite anatomical (e.g., Geshwind and Levitzky, 1968) and psychological studies (e.g., Buffery, 1971) as supporting their hypothesis. Andreassi and Juszczak (1982) obtained visual ERPs while male and female subjects observed apparently moving stimuli (a visuo-spatial-temporal phenomenon) displayed in left, central, and right visual fields. Under conditions of central visual field stimulation, females showed asymmetric brain responses to apparently moving stimuli while males did not. That is, event-related potentials (ERPs) for females were larger in amplitude for right hemisphere derivations than for left hemisphere responses. It was speculated that the findings might reflect a right hemisphere sensitivity in females for apparently moving (visuo-spatial) stimuli. These findings support the possibility of greater right hemisphere sensitivity in females for at least one kind of visuo-spatial stimulus. Most research findings, however, support the notion of greater lateralization with males and bilateralization with females

(McGlone, 1980).

The purpose of the present study was to examine visual field effects in the discrimination of line orientations while ERPs were obtained from over left and right hemispheres of the brain. Previous research has shown ERPs, particularly late positive components appearing between 250 and 600 msec after stimulus presentation (originally termed P300 by Sutton et al., 1965), to be associated with a variety of cognitive activities such as decision making, stimulus probability, evaluation, and discrimination of stimuli (for a review see Pritchard, 1981). Thus, it is expected that late positive components will emerge as well as the early sensory components related to the presentation of the stimulus.

Donchin (1979) and Duncan-Johnson and Donchin (1977) suggested that P300 latency is dependent upon the time it takes a person to complete an evaluation of a stimulus, i.e., longer P300 latencies reflect greater stimulus evaluation time. For example, Squires et al., (1977) found that P300 latency to an 1100 HZ tone was 60 msec longer when paired with a 1060 HZ tone than when paired with a 1000 HZ tone, i.e., longer P300 latencies were associated with the more difficult discriminations. In a study originating in this laboratory (Andreassi and Juszczak, 1981), it was found that P300 latencies were significantly longer during "ambiguous" visual discriminations as compared to "clear" discriminations. The ambiquous discriminations were ones where subjects were required to judge which was longer when comparison and standard lines were of the same length, while clear discriminations were possible

when the comparison and standard lines were of disparate length.

Johnson (1981) proposed that P300 amplitudes can be said to be influenced by probability, task information, and equivocation. By equivocation, Johnson refers to the subject's uncertainty about whether they have correctly perceived an event. The inverse of this, he notes, is information transmission. Variables belonging to this dimension are those that affect either the perception of the stimulus (e.g., discriminability), or those that affect the subject's attention (such as instructions to "attend" or "ignore"). He additionally notes that the term "task relevance" has frequently been used to categorize manipulations that affect the direction of the subject's attention. An example of this would be studies that use attend vs ignore instructions.

If one considers the line orientation discrimination paradigm with respect to suggested hemispheric specialization (e.g., Umilta et al., 1978; Koss, 1981), and in revealing male-female differences (Sasanuma and Kobayashi, 1978), it seems reasonable to hypothesize that males will show a LVF superiority in our discrimination task while females will not. In addition, we expect that, overall, males will show better discrimination performance than females. In reference to the ERPs, the questions that we will address are: 1) Will the ERP be related to discrimination performance? 2) Will there be hemispheric ERP differences with line discrimination e.g., will right hemisphere responses be larger? These questions will be asked with respect to the latency and amplitude measures of the major ERP components.

Method

<u>Subjects</u>: The subjects were six male and six female right-handed students associated with the City University of New York. They ranged in age from 18-30 years. Each subject was administered a vision test battery with a Bausch and Lomb Orthorator, and a handedness questionnaire (Annett, 1970). The vision test battery screened subjects for vertical and lateral phoria, and binocular visual acuity (both at near and at a distance). The handedness questionnaire asked subjects to report the preferred hand used in a variety of tasks and to indicate any familial history of left-handedness. All subjects met the criteria of normal visual acuity (corrected to at least 20/25 with glasses) and eye muscle balance (Orthophoria) as established by the Bausch and Lomb Occupational Vision Standards. None reported any personal or familial history of left handedness.

<u>Apparatus and Procedure</u>: Subjects were seated in an electrically shielded sound attenuated IAC chamber while EEG was recorded from O_1 and O_2 (Ten-Twenty System, Jasper, 1958) with Grass silver cup electrodes referenced to a silver cup electrode on the subject's left ear lobe. A Beckman Type RM Dynograph was used to record the EEG and the 9806 coupler of the Dynograph conditioned the EEG signal (bandpass set at 0.5 to 32.0 Hz). A Mnemotron Computer of Average Transients (CAT 1000), under program control of a PDP8/E computer, obtained EEG samples of 500 msec duration following presentations of the stimulus to the subject. The resultant summated Visual ERP trace was plotted on a Hewlett Packard X-Y plotter.

Eye blinks and eye movements were recorded with a two channel eye movement monitor (Washington University resetting differential amplifiers) and were measured by placing two biominiature electrodes above and below the left eye. The resultant electro-oculogram (EOG) was displayed continuously on a voltmeter in the Washington University apparatus and on a Tektronix dual-trace oscilloscope. Artifacts produced by such eye movements appeared as left or right deviations from zero on the EOG device and as abrupt changes from baseline on the storage oscilloscope. Any trials suspected of contamination were discarded.

The stimuli were displayed on a Digital Equipment Corporation VR-14 CRT which was mounted at the subject's eye level outside the chamber at a distance of 114.3 cm (45 in.). The VR-14 was controlled by the PDP8/E to deliver stimuli at specific times and locations on the CRT. The disappearance of the stimuli was virtually immediate (50 usec) with the brief persistence P24 phosphor specially installed in the VR-14.

A 1.0 cm line was displayed on the CRT for 20 msec in either a 50° or 55° orientation (measured from horizontal) in left, central, or right visual fields (see Figure 1). The presentation of the lines was randomized[1] so that subjects could not predict the line orientation

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[1]Randomization was restricted in that each line line appeared in each visual field an equal number of times.

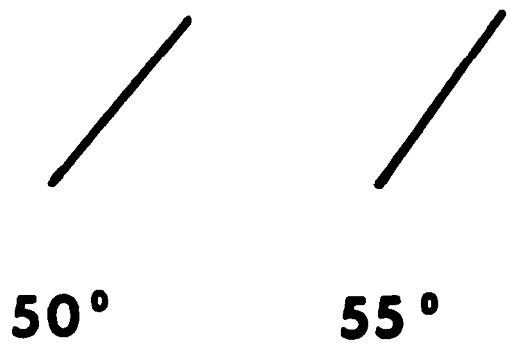

Figure 1 - Orientations of 50 deg. and 55 deg. lines. The lines were never presented simultaneously.

nor the visual field in which it appeared. For example, a 50° line might appear in the LVF followed by a 55° line presented in the right visual field (RVF). The time interval between presentations was four seconds. The probability of a given line (.50) within a visual field (.33) was .17. The CAT was under control of the experimenter so that selected EEG samples could be obtained for each line and visual field within the sequence. Each ERP trace was based on the average of ten samples, i.e., trials containing EOG contamination were repeated. Each line was presented, in the same horizontal plane, 2° 30' of arc to the left and right of fixation and directly below (6mm) the fixation point (.001 mL red neon light). Hence there were six experimental conditions: LVF-50° line,LVF-55° line, CVF-50° line, CVF-55° line, RVF-50° line, and RVF-55° line. The 1.0 cm line produced a visual angle of 30' of arc at the viewing distanced used. The luminance of each line was 2.0 mL as measured by a Tektronix J-16 photometer. Thus, in all conditions the physical parameters of the stimuli were equated.

After subjects were seated in the IAC chamber they were given the following instructions to read prior to being given practice trials:

> A line will be presented in one of two orientations to the left, right, or just below the small red neon light on the screen. Your task is to identify the more vertical (55°) line by saying YES. When the less vertical (50°) line appears say NO. Also, you are to rate how sure you are of your judgment. Use the number 4 if you are ABSOLUTELY CERTAIN, the number 3 if you are REASONABLY CERTAIN, the number 2 if you are HALF CERTAIN, and the number 1 if you think you had to GUESS. Give your answer out loud about one second after the stimulus appears.

All judgments were absolute, i.e., the two lines never appeared on the screen at the same time. After these instructions the computer was programmed to display the stimuli for 4000 msec to enable longer duration examination by subjects of both the more vertical (55°) and the less vertical line (50°). Subjects were also advised to avoid anticipating any stimuli within the visual fields, i.e., they were told that the order of presentation was completely randomized so that it would be virtually impossible to predict the line orientation and location. The subjects were given a practice period before the beginning of the experiment to insure proper performance. All reported familiarity with the appropriate response and the certainty of judgment scale at the end of this practice segment. Subjects were reminded to fixate on the red neon light at all times to avoid missing stimuli. They were also asked to look and not stare at the fixation point. This additional instruction minimized the problem of eye strain and tears, a problem often associated with prolonged fixation. The verbal responses were monitored via an intercom system and recorded by the experimenter. The six conditions were randomized across subjects over a period of two days for a total of 12 ERP traces from O_1 and O_2 for each subject.

Results

Performance Data - The main performance data are those concerning the subject's discrimination of the two line orientations, i.e., the the total number of correct discriminations out of 120 stimulus presentations for the 50° and 55° line orientations. The scores for the

two lines were also combined to obtain an overall discrimination score. These were expressed as total number of correct discriminations out of 240 stimulus presentations (i.e., 50° + 55° accuracy score). Table 1 shows the accuracy data for males, females, and males and females combined. Figure 2 graphically depicts the data from the table. A secondary dependent variable was the confidence rating regarding the discriminations. First we will present the accuracy data.

Visual Field of Presentation - The log-transformed discrimination data for males and females were subjected to analysis of variance (ANOVA) using a fixed model, two-way analysis (Gender X Field). When the combined accuracy data for all 12 subjects were considered, there were no significant visual field differences (Field, $F= 6.22$ (2/2) $p >$ .05), but there was a difference for Gender, $F=30.30$ (1/2), $p < .05$ Separate two-way ANOVAs for males and females (Subjects X Field) with only LVF and RVF compared, revealed a significant visual field effect for males, $F=10.19$ (1/5) $p < .01$, but not for females $F=$ (1/5) < 1.

Table 1
Percent Correct Discriminations
Within Three Visual Fields for Males, Females
and Males and Females Combined (combined accuracy score)

	LVF	CVF	RVF
Males (N=6)	88	89	85
Females (N=6)	80	84	76
Combined (N=12)	84	87	80

Note that for males, females, and the two combined, LVF accuracy scores

were better than RVF scores, but only the male scores were statistically significant. This is due to the fact that all six male subjects showed better performance for LVF discriminations while three of the females had reversals, i.e., more accurate RVF discriminations. This reversal for the three females is highlighted by the significant Subject X Field interaction effect found for this group, ($F=3.13$ (5/12), $p < .05$). Moreover, Figure 2 also shows that across the three visual fields, males were better at discriminating the two lines than females. This is reflected in the significant Gender effects mentioned previously. We also conducted t-tests for uncorrelated data to examine male - female performance differences within each visual field. These were found to be non-significant (LVF, $t=1.33$; CVF, $t=1.54$; RVF, $t=1.65$: 10 df, $p > .05$ for all) and indicated that the overall discrimination performance among males was not due to any particular visual field superiority (e.g., LVF males vs LVF females), but rather that, in general, males were better at the task than females. In addition, accuracy scores for CVF presentations tended to be higher, as one might expect, since these involve foveal discriminations. However, additional t-tests for peripheral versus central visual field comparisons for males, females, or males and females combined failed to reach significance ($p > .05$).

Line Orientation - A three-way ANOVA (Gender X Field X Line Orientation) was conducted on the log - transformed discrimination data. The line orientation variable was significant, $F=3.92$ (1/71), $p < .05$. This indicated that across all 12 subjects and three visual

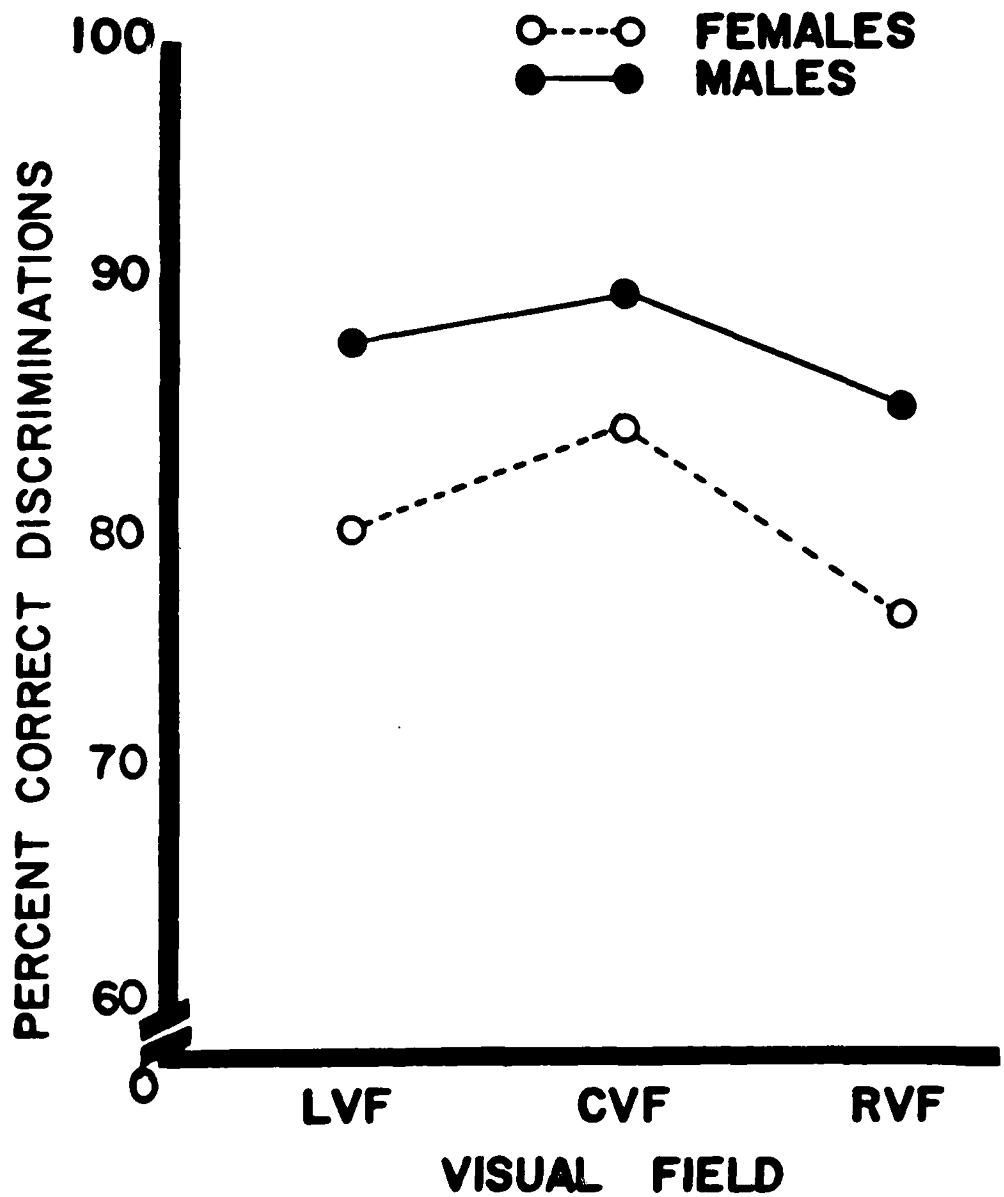

Figure 2 - Percent correct discriminations of the 50 deg and 55 deg line orientations combined (240 presentations) for males and females.

fields, discrimination accuracy was better for the 55° line orientation (87% correct) than the 50° line (80% correct). However, when this difference was examined more closely, the better performance with the 55° line was found to be due to a response bias. That is, there was a greater tendency for subjects to say "yes" (54%) than "no" (46%), over the course of the entire experiment. This response bias worked in favor of the line to which a "yes" was required, i.e., the 55° line. This response bias operated equally in the three visual fields (55% vs. 45% in LVF, 53% vs. 47% in CVF, and 53% vs. 47% in RVF).

Confidence Ratings - Mean confidence ratings for each subject and visual field were computed for males and females. A Mann-Whitney U-test was used to examine confidence rating differences between these two groups and was found to be non-significant ($U=9.5$, $p > .05$). There was, however, a trend in which males tended to express more confidence in their judgments than females, i.e., males had a mean rating of 3.4 and females 2.8 out of a possible 4.0.

Visual ERPs - The ERP traces of all subjects showed several components from which the latency and amplitude measurements were made. Latencies - Four components were identified; N2, P2, N3, and P3. The N2 component was taken as the peak of a large negative wave appearing between 150 and 175 msec post-stimulus in the 500 msec sample. A positive peak immediately following N2 and appearing between 200 and 230 msec was termed P2. The N3 component appeared between 240 and 280 msec. The P3 component was a second large positive peak occurring

between 300 and 400 msec post-stimulus. If the peaks appeared more as a plateau the midpoint of the plateau was taken as the latency measurement.

Amplitudes - Two major components were analyzed with regard to amplitude. These were N2-P2, and N3-P3. For N2-P2, the measurement in microvolts (uV) was made as the vertical distance from the peak of N2 to the peak of P2. The N3-P3 amplitude component was measured in a similar way, i.e., the vertical distance from N3 to P3. In 5% of the traces the N3 component was absent. For these traces the amplitude measurement was made from baseline. Figures 3 and 4 show the ERP traces of one male and one female subject recorded at both scalp locations under the six experimental conditions. The small vertical bars indicate the selection of the P3 component as the first positive response to occur between 300 and 400 msec post-stimulus.

N2-P2 amplitude - The main statistical test used to analyze this component was a 3-way ANOVA (Gender X Conditions X Placements). Although the Gender effect was non-significant, $F\ (1/143) < 1$, we did obtain significance for the Condition X Placement interaction, $F=4.20\ (5/143)$, $p < .01$. Separate ANOVAs for males and females also revealed a significant Condition X Placement effect, males, $F=5.41\ (5/71)$, $p < .01$; Females, $F=2.47\ (5/71)$, $p < .05$). Table 3 shows N2-P2 amplitudes and N2 latencies for males, females, and the two groups combined. Figure 5 graphically depicts the amplitude data for the combined groups.

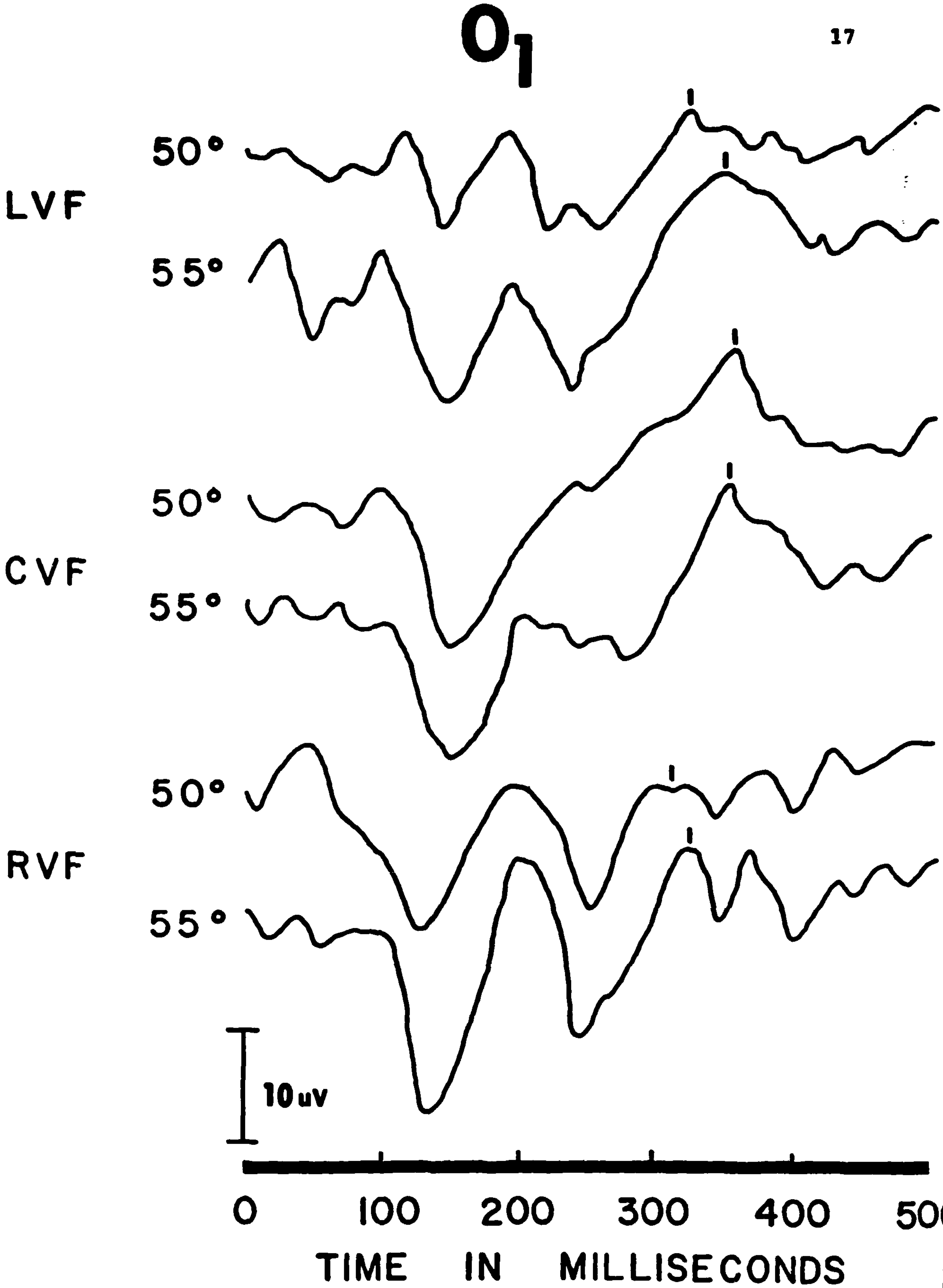

Figure 3 - Visual ERPs of one male subject (L.A.) recorded from O_1 (left hemisphere). The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

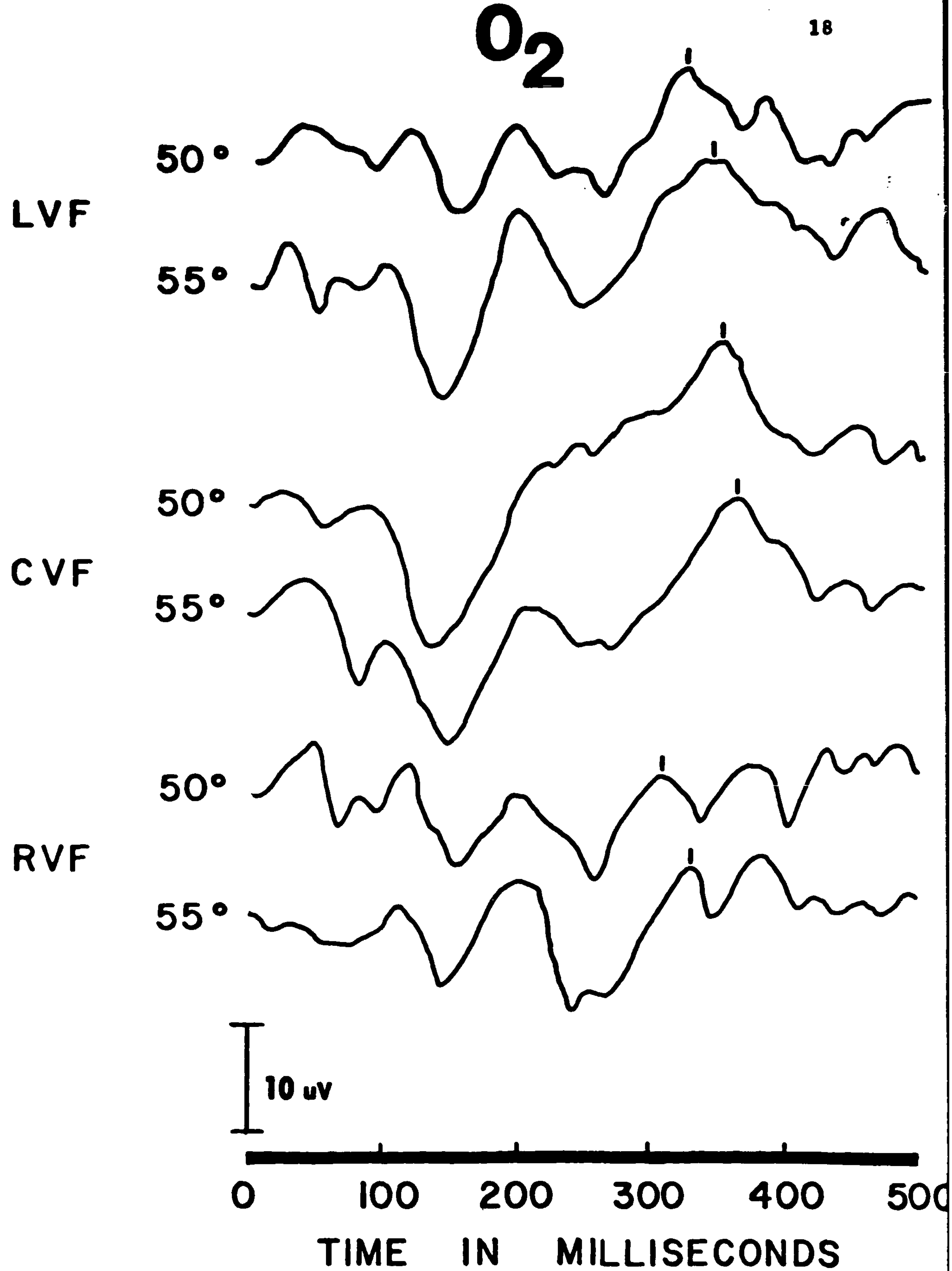

Figure 3 - Visual ERPs of one male subject (L.A.) recorded from O_2 (right he[illegible]sphere). The vertical bars indicate the P3 component, i.e., the first posit[illegible]e component occurring between 300 and 400 msec post-stimulus. Negativi[illegible]y is downward.

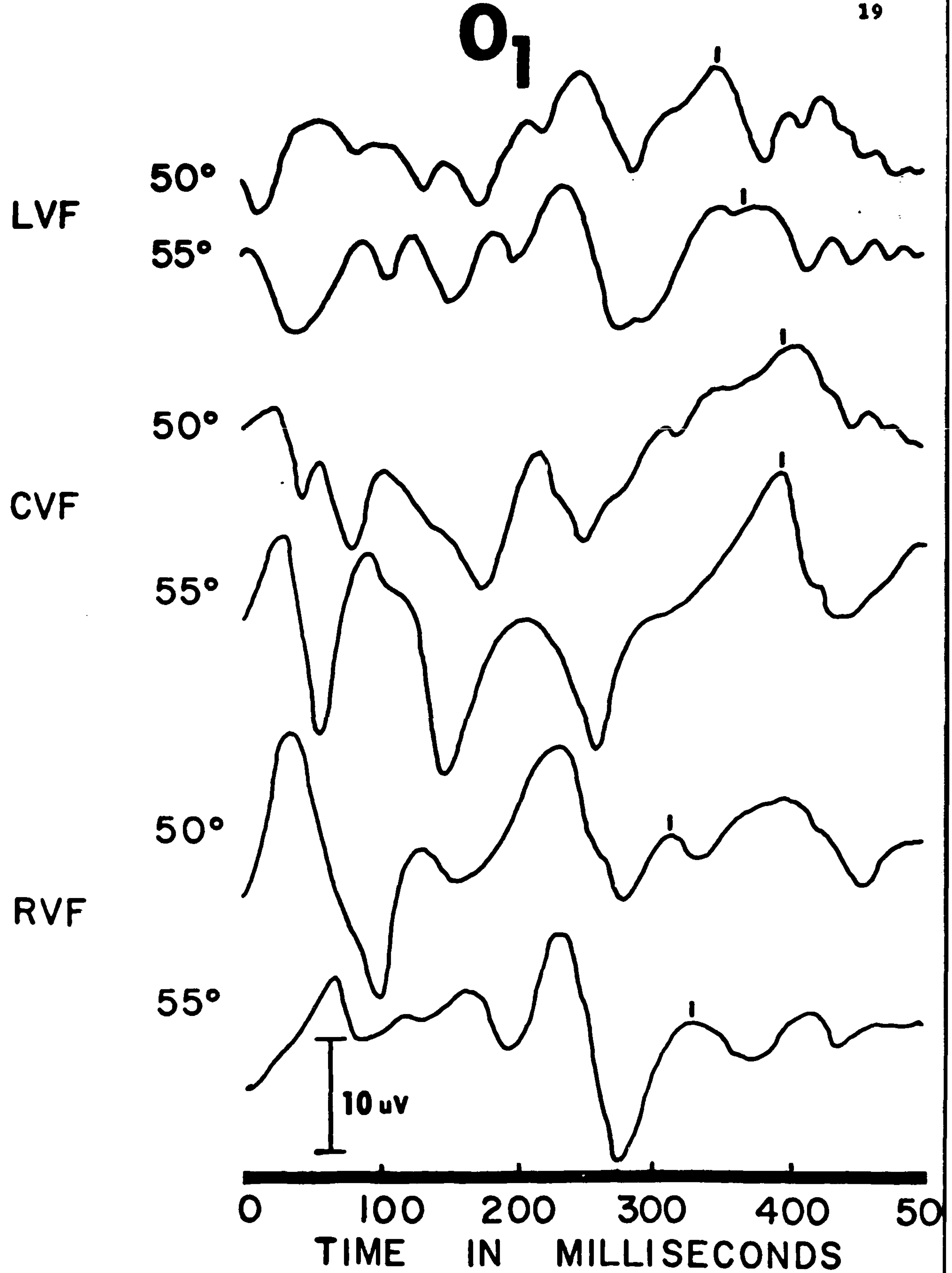

Figure 4 - Visual ERPs of one female subject (M.K.) recorded from 0_1 (left hemisphe
The vertical bars indicate P3, i.e., the first positive component occurr
between 300 and 400 msec post-stimulus. Negativity is downward.

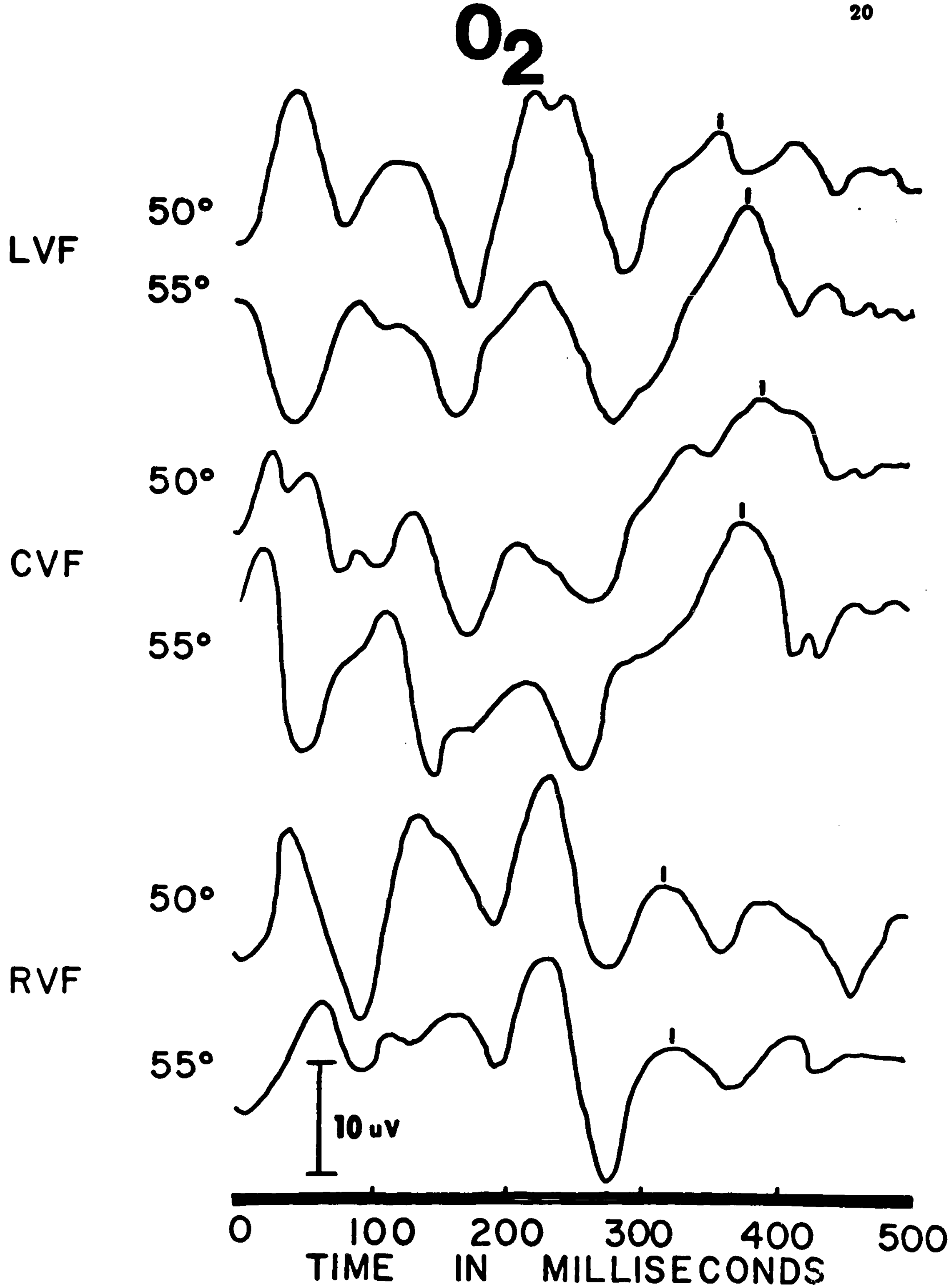

Figure 4 - Visual ERPs of one female subject (M.K.) recorded from O_2 (right hemisphere). The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

Table 3

Mean Latency (msec) and Amplitude (uV) for Visual ERP
Components N2, and N2-P2 for Males, Females
Males and Females Combined for Placements and Conditions

	O_1						O_2					
	(N=6) Males		(N=6) Females		(N=12) Combined		(N=6) Males		(N=6) Females		(N=12) Combined	
	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2
LVF 50°	162	10.3	167	14.0	165	12.2	156	14.5	160	18.0	158	16.3
LVF 55°	155	12.6	169	13.8	162	13.2	150	15.8	159	18.2	155	17.0
CVF 50°	155	18.3	158	15.0	157	16.7	154	18.6	159	13.8	157	16.2
CVF 55°	155	16.9	157	15.8	156	16.4	152	16.2	155	15.0	154	15.7
RVF 50°	148	17.1	158	13.1	153	15.1	169	11.9	167	11.2	168	11.6
RVF 55°	155	15.5	154	13.6	155	14.6	172	8.8	172	10.1	172	9.5

Several Newman-Keuls multiple comparison tests were conducted to examine these significant effects in greater detail. When considering line orientation comparisons within each visual field, there were no significant differences (i.e., LVF 50°, vs LVF 55°, CVF 50° vs CVF 55°, RVF 50° vs RVF 55°, with $p > .05$). We did obtain significant amplitude differences when responses to the lines within each visual field were combined to allow for more direct visual field comparisons. For example, we found that right hemisphere amplitudes were significantly larger than left hemisphere amplitudes with LVF presentations. Conversely, left hemisphere amplitudes were larger than right with RVF presentations. These significant findings were obtained for the two groups combined, $p < .01$; males, $p < .01$; and females, $p < .05$. Note in Table 3 and Figure 5 that the amplitude component shows the expected response advantage when the left and right hemispheres are

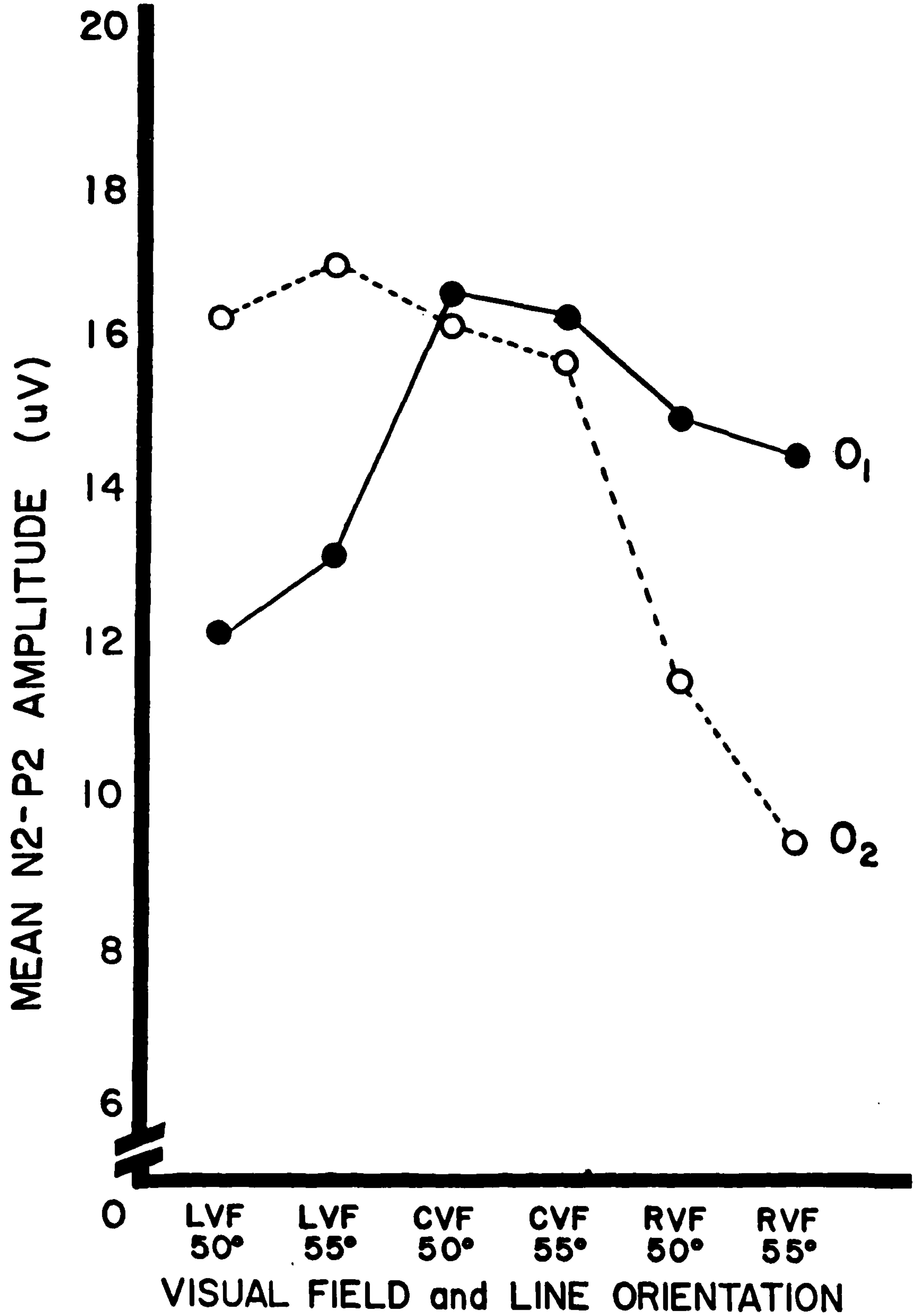

Figure 5 - Mean amplitude of the N2-P2 component of the visual ERP as recorded from O_1 and O_2 for males and females combined (N=12).

differentially stimulated, i.e., amplitudes are larger at the recording site contralateral to the field of presentation. This trend emphasizes fact that this N2-P2 component is stimulus bound.

N3-P3 Amplitude - A 3-way ANOVA on all 12 subjects (Subjects X Condition X Placements) compared responses to the 50° line orientation with responses to the 55° line (left, central, and right visual fields combined). A significant condition effect was obtained, $F=14.2$ $(1/24)$, $p < .05$. The data used for the above analyses are presented in Table 4 and depicted in Figure 6.

Table 4

Mean Latency (msec) and Amplitude (uV) of the Visual ERP Component N3-P3 of Males, Females, and Males and Females Combined, for Placements and Conditions

	O_1						O_2					
	Males		Females		Combined		Males		Females		Combined	
	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP
LVF 50°	321	9.6	309	13.3	315	11.4	323	9.4	309	13.1	314	11.2
LVF 55°	320	13.3	327	14.0	324	13.7	315	12.1	328	13.4	322	12.7
CVF 50°	328	10.7	330	17.1	329	13.9	328	10.7	329	19.2	328	15.0
CVF 55°	321	14.2	328	18.6	325	16.4	320	15.6	328	19.0	324	16.9
RVF 50°	314	9.7	319	10.9	316	10.3	315	10.3	321	12.0	318	11.1
RVF 55°	322	10.8	323	14.3	323	12.6	323	9.4	320	16.4	322	12.9

The table reveals that for all three possibilities (males, females, combined), N3-P3 amplitudes were larger to the 55° line orientation than to the 50° line. Although, the female difference failed to achieve significance, ($p < .10 > .05$), it was strong enough to suggest that this

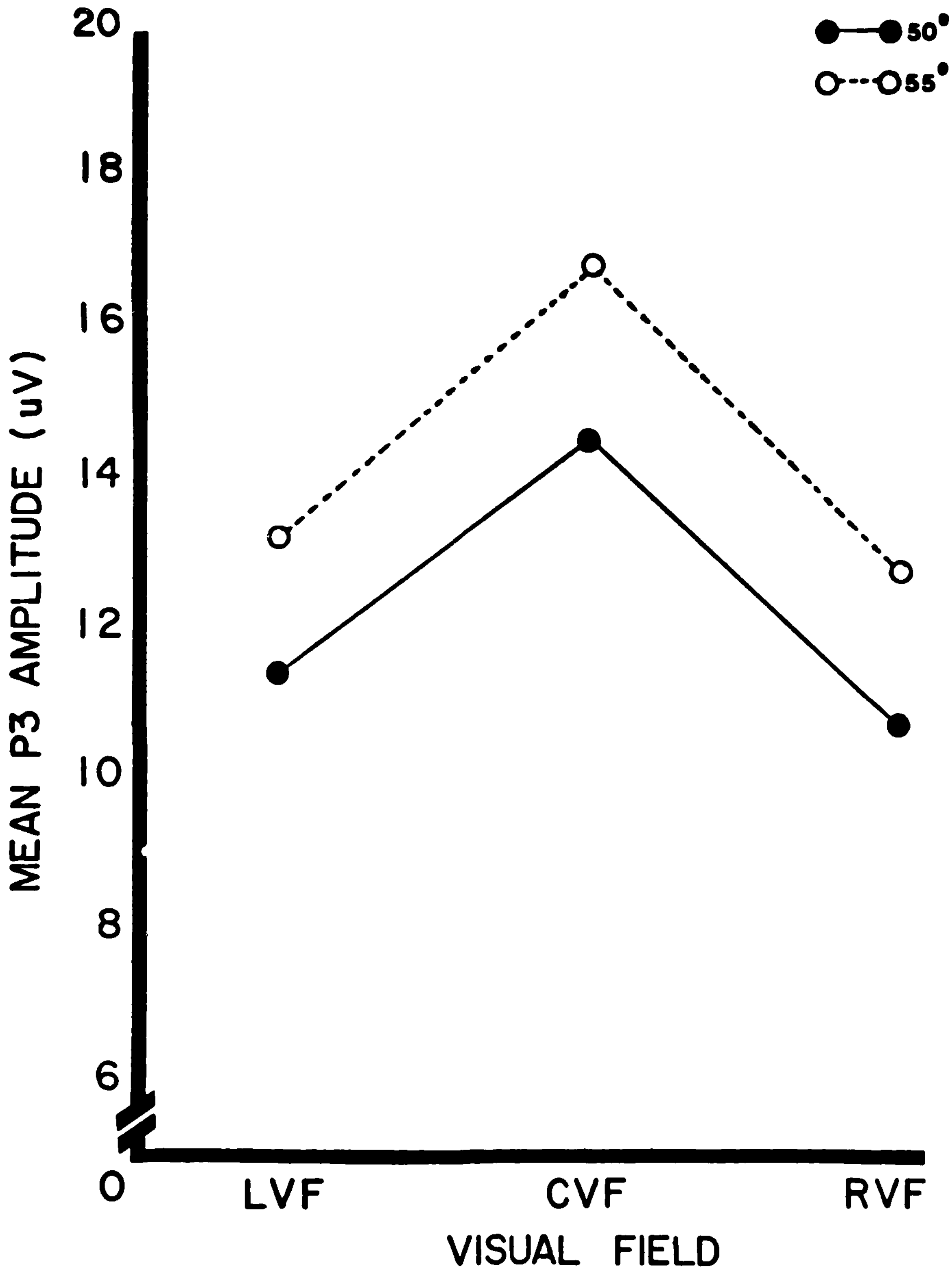

Figure 6 - Mean amplitude of the P3 component for two line orientations, and three visual fields.

amplitude advantage was at least a trend. A Newman-Keuls multiple comparison test (Winer, 1971) was used to examine this effect for the left and right hemisphere recording sites (i.e., 0_1 and 0_2). Both showed a similar trend, i.e., larger N3-P3 amplitudes to the 55° line, but only the right hemisphere showed significantly larger responses (they were, 0_1-55° line = 14.2 uV, 50° line = 11.9 uV, $p > .05$; 0_2 55° line = 14.2 uV, 50° line = 10.4 uV, $p < .01$.).

<u>N2 latency</u> - Similar to the combined ANOVA on N2-P2 amplitude, the 3-way ANOVA (Subject X Conditions X Placements) showed a significant Condition X Placement interaction, F=6.92 (5/143), $p < .01$. In addition, significant Condition X Placement interaction effects were also obtained in the separate 3-way ANOVAs for males and females (Males, F=5.08 (5/71), $p < .01$; Females, F=3.71 (5/71), $p < .01$). The N2 latency data are shown in Table 3 and graphically represented in Figure 7. Thus, N2 latencies show contralateral visual field effects. Namely, latencies were shorter at the recording site contralateral to the field of presentation. Newman-Keuls multiple comparison tests further examined this finding for males and females separately and for both groups combined. They revealed that within LVF presentations, latencies at the right hemisphere (0_1) were significantly shorter than latencies at the left hemisphere (0_2) (with $p < .01$ for Males; $p < .05$ for females; and $p < .01$ for combined). When the multiple comparison tests were used to compare latencies between the 50° and 55° line orientation within the three visual fields, there were no significant differences for either males, females or the two combined ($p > .05$ for all). Finally, the

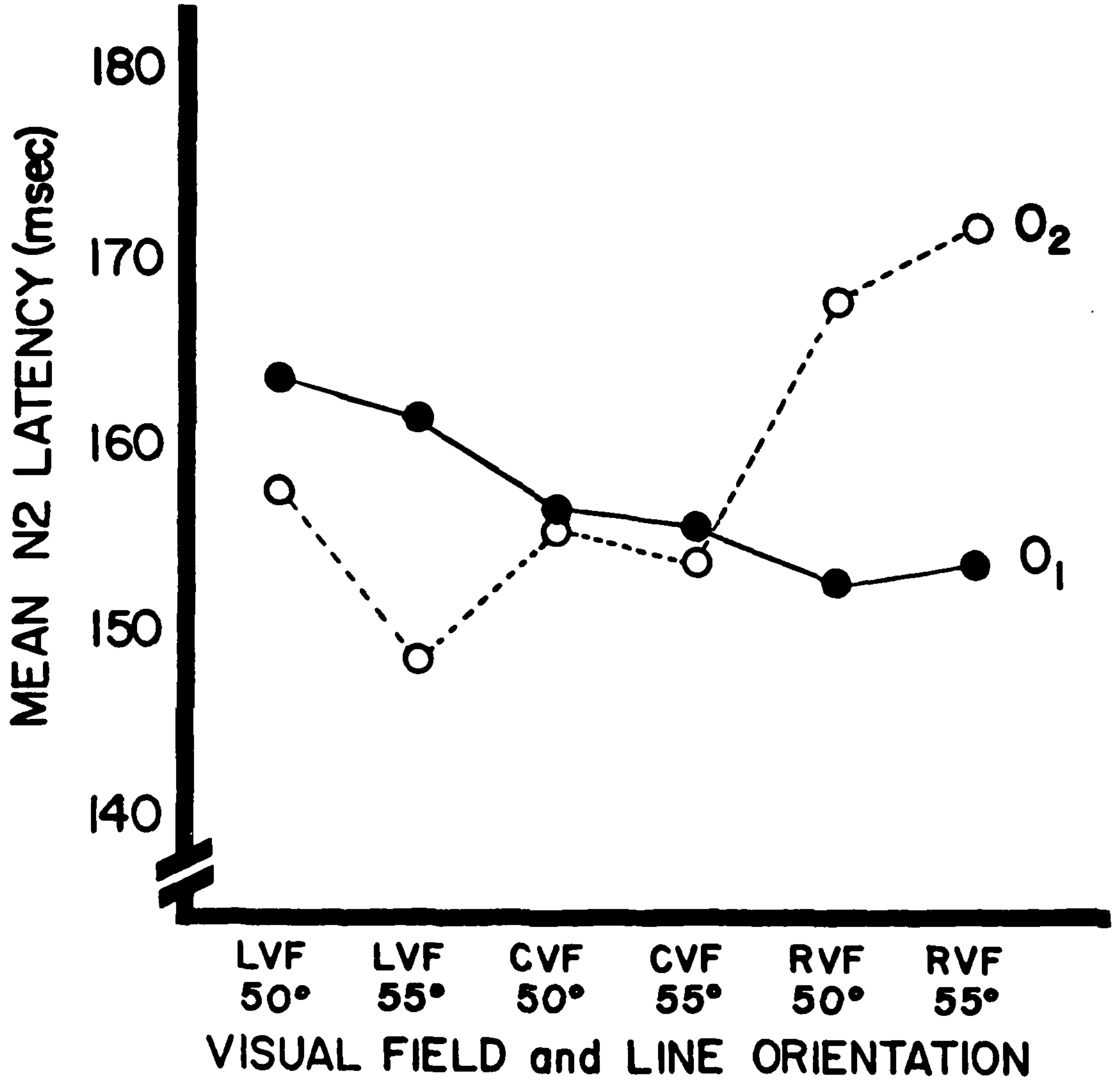

Figure 7 - Mean latency of N2 component of visual ERP as recorded from O_1 and O_2 for males and females combined (N=12).

ANOVA that examined possible Gender effects (Gender X Conditions X Placements) was also non-significant (F=1.24 (1/143), $p > .05$).

P2 latency - The only significant finding for this component was obtained in a 3-way ANOVA which examined possible Gender differences (Gender X Condition X Placement). For Gender it was F=3.90 (1/143), $p < .05$. The mean P2 latency for males and females, across placements, and conditions was 220 and 214 msec respectively. Thus, for females, latencies were on the average 6 msec faster than for males.

P3 latency - A 3-way ANOVA (Subject X Conditions X Placements) was computed to examine the possibility that P3 latencies would also show differential responses to the two line orientations. The computed F-ratio, however, failed to reach significance, F=2.91 (1/143), $p > .05$ for Condition effects). When Gender is considered as a factor in the ANOVA (Gender X Conditions X Placements), there were no significant differences between males and females, $F < 1$. The mean P3 latencies for males, females and the two groups combined are shown in Table 4 with the N3-P3 amplitude data.

Discussion

The performance data utilizing combined accuracy scores supported the main hypothesis of this study. Namely, that right hemisphere discriminations would be superior to the left, but only for males. This is consistent with results of Sasanuma and Kobayashi (1978), who

found that males showed a LVF superiority in a task requiring recognition of the direction of lines. They also noted that almost half of their female subjects had superior RVF discrimination performance or showed no visual field differences (6 of 14). In our study, three of the six females had better RVF discrimination scores. In a study with six male subjects, Koss (1981) found superior right hemisphere performance in a line orientation discrimination task similar to ours. We suggest that the LVF superiority found with our male subjects reflects greater efficiency of the right hemisphere in the processing of visuo-spatial information. The fact that females did not produce similar results suggests bilateral representation of visuo-spatial functions in the female brain. This notion is consistent with the research literature suggesting that male brains may be more lateralized with respect to linguistic and visuo-spatial abilities, while the female brain may show bilateral representation of these same functions (for a review see Harris, 1978).

Another finding was that, overall, males were superior to females in their discriminations as reflected in the higher accuracy scores found among males. The question that arises is whether the male performance superiority was due to the greater lateralization of visuo-spatial functions in the right hemisphere of the male brain or perhaps, to culturally prescribed experiential factors. In other words, does early practice in visuo-spatial and perceptual motor activities, particularly skills that include the exploration and manipulation of objects (e.g., toys, mechanical tools, sports) favor

male performance in spatial discrimination tasks? This question was also addressed by other researchers who used several cognitive and perceptual-motor tasks in which males were found to excel (e.g., WISC Block Design test, Berlin and Languis, 1980; rotary pursuit, Noble and Noble, 1972). It appears that the performance superiority found in our study could be explained by the possibility that males may have acquired the type of experience that would facilitate performance in the type of task used in our study, i.e., visuo-spatial discrimination. This notion is supported by the finding that performance superiority for males was consistent within each of the three visual fields, it was not only a LVF superiority, and that males tended to express more confidence in their discriminations than females.

An unexpected finding was the larger P3 amplitudes with the 55° line as compared to the 50° line. This effect was observed in each visual field and for both males and females. Perhaps the key here was the different instructions given to the subjects with regard to the two lines. The fact that subjects were required to identify and say "yes" to the 55° line and "no" to the 50° line may have led them to consider the 55° line as more important or relevant. Did the positive nature of the response category "yes" cause subjects to attribute more relevance to this line?

We have planned a follow-up study in which subjects will be required to say "yes" to the 50° line and "no" to the 55° line. If the P3 amplitude advantage switches to the 50° line then their larger

P3 amplitude could be related to giving a "yes" response to a stimulus. There was a response bias in favor of saying "yes" (54%) vs. "no" (46%). This response bias may be related to some implicit cognitive process which makes it more significant to say "yes" than to say "no".

Thus, in the present experiment, we have found that P3 amplitude (the component related to the discrimination - decision process) was larger to a line which required a "yes" response. We propose that P3 amplitude reflects some implicit cognitive act which attributes greater importance or relevance to a stimulus which requires a positive response. In our follow-up study we predict that P3 amplitude will be larger to a 50° line since this line will require a "yes" response. The follow-up will also enable us to determine the reliability of the superior LVF (right hemisphere) discriminations for male subjects.

The fact that the earlier components (N2 latency and N2-P2 amplitude) showed contralateral visual field effects indicate that they are stimulus bound, while the later component, P3 is sensitive to the discrimination task itself, and also apparently, to the differential instructions. We found, too, that females produced significantly shorter P2 latencies than males. A similar finding was observed in an earlier study (Andreassi and Juszczak, 1982) in which females produced shorter N2 latency responses than did males to apparently moving stimuli. The tentative explanation offered for this finding was that the female brain is, on the average, smaller than the male brain, and therefore, neuronal transmission time may be faster.

Experiment II: Event Related Brain Potentials During Velocity Discriminations in Three Visual Fields: Hemispheric and Sex Differences

In a previous study Andreassi and Juszczak (1982) found that under conditions of central visual field stimulation, females showed asymmetric brain responses to apparently moving stimuli while males did not. That is, event-related potentials (ERPs) for females were larger in amplitude for right occipital hemisphere derivations than those recorded from over the left hemisphere. It was speculated that the findings might reflect a greater right hemisphere sensitivity in females for apparently moving (visuo-spatial) stimuli. A question that arises is whether the amplitude advantage observed in females is related to superior performance in discriminating motion. Therefore the present experiment was designed to examine two main problems:
1) Motion discrimination performance and related brain potentials of right and left hemispheres of the brain; 2) Possible sex differences in discriminating velocity of motion.

The literature suggests that the right hemisphere of the brain is lateralized with respect to visuo-spatial abilities, especially for males. This right hemisphere specialization has been found in studies using strictly perceptual measures (DeRenzi, 1978; Sasanuma and Kobayashi, 1978; Koss, 1981) and those using both behavioral and electrophysiological responses (Furst, 1976; Rebert and Low, 1978; Robertshaw and Sheldon, 1976).

There is some disagreement regarding the degree to which males and females evidence brain lateralization with respect to various functions.

Harris (1978) suggests that the male brain is lateralized with respect to linguistic and visuo-spatial functions, while in females the two hemispheres participate equally in these same activities. A contrasting position has been taken by Buffery and Grey (1972), who proposed that females are lateralized along the linguistic visuo-spatial dimension while males are more bilateralized. The issue is not settled and may even depend on the type of verbal task or type of visuo-spatial task used.

Studies of brain response and motion are not numerous. An early investigation (Barlow, 1964) showed that evoked potentials could be produced by sudden changes in the vertical position of a spot on an oscilloscope. Clarke (1974) produced VEPs through reversals in the horizontal motion of a visual noise pattern. The velocity of motion was 10 degrees of visual angle per second. Clarke suggested that motion-reversal VEPs were produced largely by direction-sensitive mechanisms within the human brain. Coffin (1977) presented subjects with different velocities of apparent motion while EEG was measured. He found higher frequency alpha-range EEG at a midline occipital placement, with the higher velocity "strong motion" conditions. There was a non-significant trend toward greater right occipital EEG frequencies, but not left, with higher velocities. The greater (non-significant) right hemisphere effect was attributed to the spatiotemporal nature of the task which allowed for some differential processing by the right ("spatial") hemisphere. Andreassi et al., (1979) reported a study in which two types of apparent motion and one stationary condition were

presented while ERPs were measured from midline, occipital, and central areas. The motion conditions were each presented at three different velocities. The continuous apparent motion condition resulted in greater VEP amplitudes and longer latencies than discrete apparent motion at the two higher velocities (19.18 deg/sec and 13.08 deg/sec). These differences were observed at the occipital but not at the central recording site. The results suggested that the human visual system processes these types of motion differently.

The strategy that we used in the current study was to have males and females make discriminations of two motion velocities projected in left, central, and right visual fields. The apparent motion used was that of a bar of light moving downwards in a vertical direction, in contrast to our previous study (Andreassi and Juszczak, 1982) in which a bar of light moved from left to right. We hypothesize that: 1) Right hemisphere discriminations will be superior to those under left hemisphere control; 2) Visual ERPs to moving stimuli will produce larger right hemisphere as compared to left hemisphere responses with CVF presentations for females.

Method

Subjects: The subjects were 9 male and 9 female right-handed students associated with the City University of New York. They ranged in age from 18-27 years. Each subject was administered a vision test battery with a Bausch and Lomb Orthorator and completed a handedness questionnaire (Annett, 1970). The vision test battery screened subjects

for vertical and lateral phoria and binocular visual acuity (both at near and at distance). The handedness questionnaire asked subjects to report the preferred hand used in a variety of tasks and to indicate any familial history of left handedness. All participating subjects met the criteria of normal visual acuity (corrected to at least 20/25 with glasses) and eye muscle balance (Orthophoria) as established by the Bausch and Lomb Occupational Vision Standards. None of the participants reported any personal or familial history of left handedness.

Apparatus and Procedure: Subjects were seated in an electrically shielded sound attenuated IAC chamber while EEG was recorded from O_1 and O_2 (Ten-Twenty System Jasper, 1958) with Grass silver cup electrodes referenced to a silver clip electrode on the subject's left ear lobe. A Beckman Type RM Dynograph was used to record the EEG and the 9806 coupler of the Dynograph conditioned the EEG signal (bandpass set at 0.5 to 32.0 Hz). A Mnemotron Computer of Average Transients (CAT 1000), under program control of a PDP8/E computer, obtained 500 msec EEG samples immediately following presentations of stimuli to subjects. The resultant summated Visual ERP trace was plotted on a Hewlett Packard X-Y plotter.

Eye blinks and eye movements were recorded with a two channel eye movement monitor (Washington University resetting differential amplifiers) and were measured by placing two biominiature electrodes above and below the left eye. The resultant electro-oculogram (EOG) was displayed continuously on a voltmeter in the Washington University Apparatus and on a Tektronix dual-trace oscilloscope. Artifacts

produced by such eye movements appeared as left or right deviations from zero on the EOG device, and as abrupt changes from baseline on the storage oscilloscope. Trials containing EOG contamination were discarded.

All stimuli in this experiment were displayed on a Digital Equipment Corporation VR-14 CRT which was mounted at the subject's eye level outside the chamber at a distance of 114.3 cm. The VR-14 was controlled by the PDP8/E to deliver stimuli at specific times and locations on the CRT. The disappearance of the stimuli was virtually immediate (50 usec) with the brief persistence P24 phosphor specially installed in the VR-14.

The experimental conditions consisted of projecting "continous *apparent motion" (CAM) stimuli in* left, central, and right visual fields at two velocities: 12.60° and 16.09° of arc per second. The motion perceived was that of a horizontal line moving down in a vertical direction. This effect was achieved by presenting a single 0.5 cm horizontal line on the screen for 3 msec, followed by 9 successive lines each on for 3 msec, with the last line 2.8 cm below the first. The distance between each line was equal (see Figure 1). Differential velocities were accomplished by varying the interstimulus interval (ISI) between each of the lines. For the 12.60°/sec CAM condition, the sum of the "ON" times of each line and the ISIs between then was 111 msec, while for the 16.09°/sec CAM condition it was 87 msec. These total display times (TDT) produced the perception of a single horizontal line

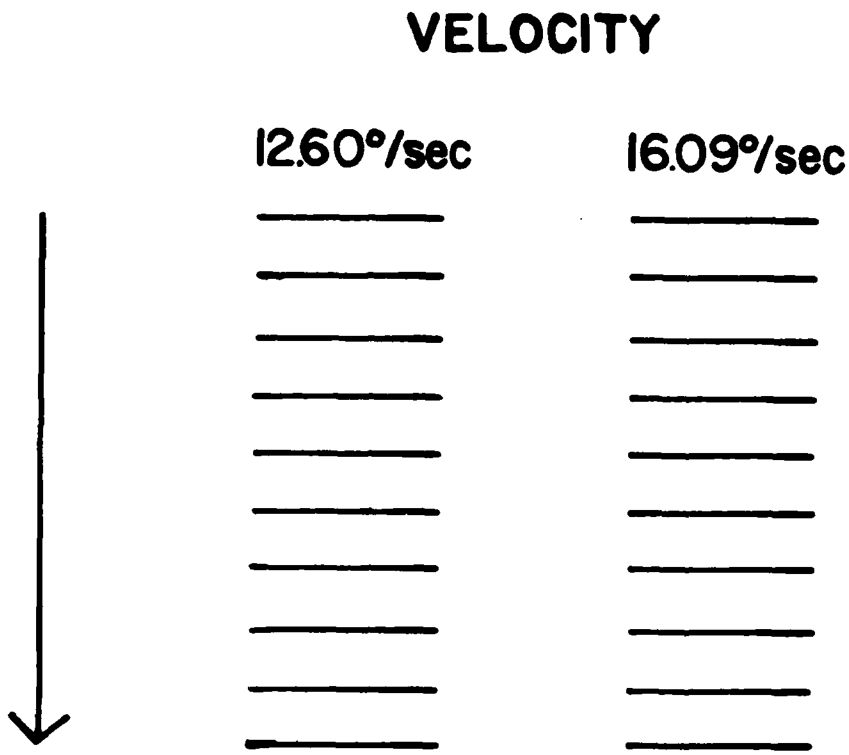

Figure 1 - The arrow shows the direction of downward apparent motion. Differential velocities were accomplished by varying the ISI between each of the lines. For the 12.60° /sec velocity the sum of the ON time of each line (3 msec) and the ISIs between them was 111 msec. For the 16.09° /sec velocity it was 87 msec.

moving downwards at two different speeds[1]. The horizontal lines were all 0.5 cm in length and the 2.8 cm separation between the first and last line produced a visual angle of 1°24' of arc. The luminance level for the combined stimuli for both CAM conditions was 6.68 mL as measured by a Tektronix J-16 photometer. Thus, luminance and spatial characteristics were equated. The lines were presented at the same initial and terminal coordinates on the CRT, 3° of arc to the left and right of fixation (measured from fixation to the near point of each line), and below (6 mm) the fixation point (.001 mL red neon light). There were six experimental conditions:

LVF - 12.60°/sec, LVF - 16.09°/sec,, CVF - 12.60°/sec, CVF - 16.09°/sec, RVF - 12.60°/sec, RVF - 16.09°/sec

The two CAM conditions were randomly displayed in the three visual fields[2]. For example, a 12.60° CAM stimuli might appear in the left visual field (LVF) followed by a 16.09° CAM stimuli presented in the right visual field (RVF). The time interval between these presentations was four seconds.

The CAT was under program control of the experimenter so that selective EEG samples could be obtained for each CAM velocity condition within each visual field. Data were collected until there were 10 uncontaminated samples in the ERP trace for each condition.

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1 These motion effects were determined in pilot trials with 18 subjects. These subjects were not part of the actual experiment.

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2 Randomization was restricted in that each CAM condition appeared in each visual field an equal number of times.

The subjects were seated in the IAC chamber and were given the following instructions to read prior to being given practice trials:

> A small horizontal line will appear to the left, right, and just below a small red light on the screen. The line will move downwards at two speeds. Your task is say "A" when the line appears to move fast and "B" when the line appears to move slower. Also you are to rate how sure you are of your judgments. Use the number 4 if you are absolutely certain of your judgment, the number 3 if you are reasonably certain, the number 2 if you are half certain, and the number 1 if you think you had to guess. Give your answer out loud about one second after the moving line appears.

All judgments were absolute, i.e., only one stimulus condition appeared on the screen at a given time. All subjects were given a six minute practice period before the beginning of the experiment to insure proper performance. All reported familiarity with the appropriate response and the certainty of judgment scale at the end of this practice period. Subjects were reminded to fixate on the red light at all times to avoid missing stimuli. The verbal responses were monitored via an intercom system and recorded by the experimenter. The six conditions were counterbalanced across subjects over a period of two days and resulted in a total of 12 ERP traces from O_1 and O_2 for each subject.

Results

Performance Data - The main performance data are those concerning each subject's discrimination of the two apparent motion velocities and are expressed as percent of combined correct discriminations (i.e., 12.60° + 16.09° arc/sec divided by 120 presentations). For the statistical analysis, the combined total number of correct discriminations were

used. The data were collected from three individual segments over a twenty minute period, with each segment consisting of 40 stimulus presentations. Thus another variable for consideration was discrimination performance over time, i.e., segment 1 scores vs segment 2 scores vs segment 3 scores. A third variable was percent correct discriminations for each apparent motion condition, i.e., correct discriminations of the 12.60° and the 16.09° condition separately.

Visual Field - A log transformed two-way analysis of variance (ANOVA) fixed model (Gender X Field) compared left visual field discriminations with those of the right visual field. While the gender effect was non-significant ($F < 1$), there was a significant field effect, $F=46.3$, (1/1), $p < .05$. Separate two-way ANOVAs (Subject X Field) for male and female data revealed that the field effect for females was significant ($F=22.56$, (1/1), $p < .01$) while for males it was not ($F=2.32$, (1/1) $p > .05$). Table 1 shows the percent correct discrimination scores for males, females and both groups combined. Figure 2 graphically depicts the information from the table for males and females.

Table 1
Percent Correct Discrimination Within Three
Visual Fields for Males, Females, and Males and Females Combined

	LVF	CVF	RVF
Males (N=9)	73	72	77
Females (N=9)	73	77	78
Combined (N=18)	73	75	78

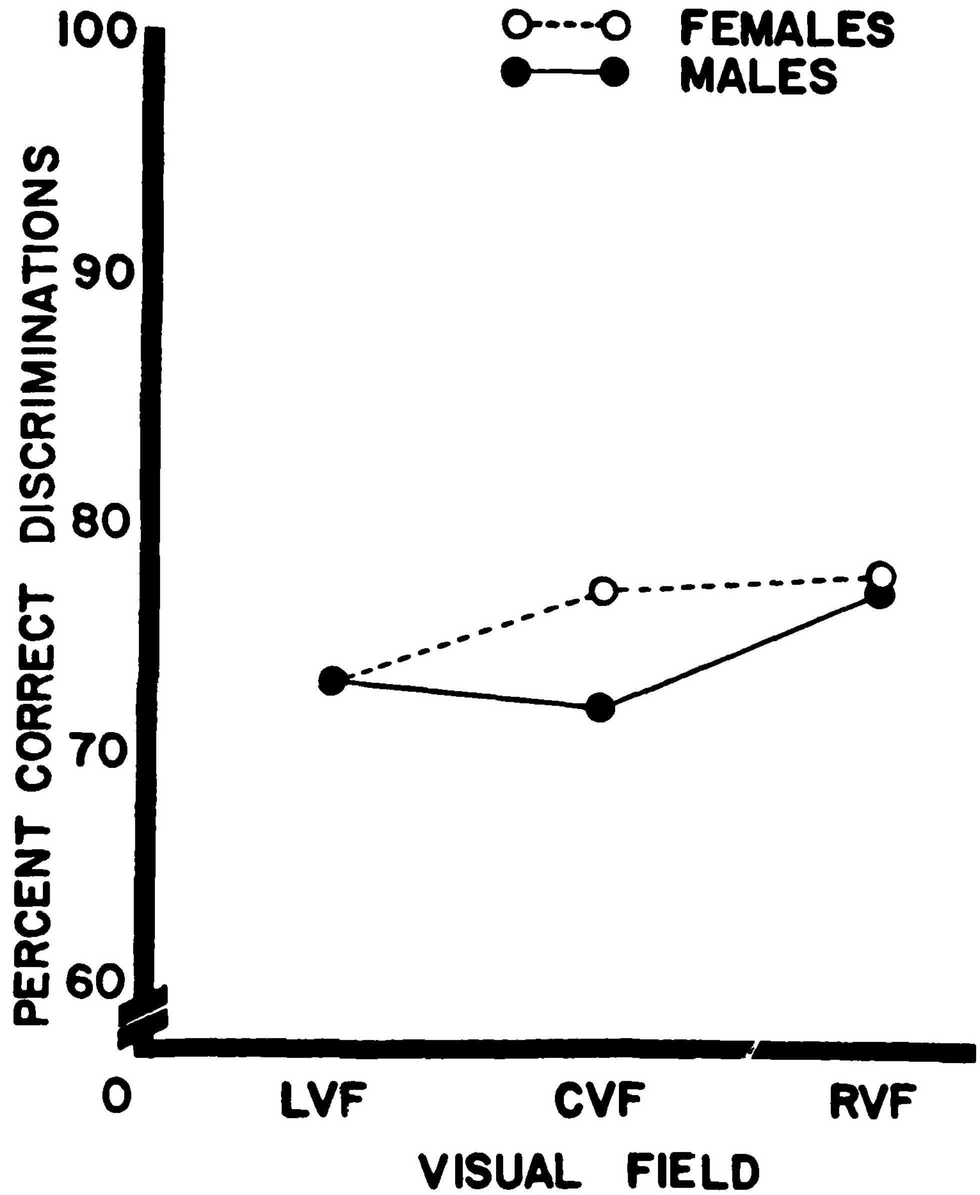

Figure 2 - Percent correct discriminations of the 12.60° /sec and and 16.09° /sec motion velocity conditions combined (240 presentations) for males and females.

The table reveals that left hemisphere (RVF) discriminations were superior to right (LVF), however the previously described ANOVA results indicated that this left hemisphere advantage was significant for the combined group and females, but not for males. An analysis of the individual male scores show that three of the nine males had better right hemisphere discriminations. Table 1 indicates that with central visual field presentations (CVF), females were on the average 5% better in their discriminations than males. A t-test for uncorrelated data, however, indicated that this advantage for females was not significant ($p > .05$).

Discrimination Performance Over Time - When males and females are considered as a group, there was a significant decline in percent of correct discriminations from segment 1 to segment 3 with RVF presentations (segment 1 vs segment 2 - $t=2.61$ 17 df $p < .05$ two tailed t-test, uncorrelated data). In contrast, the t-test results on CVF and LVF scores for the same segment comparisons were non-significant ($p > .05$). When males and females are considered separately, only the male discrimination scores showed a significant decline from segment 1 to 2 ($t=2.34$, 8 df $p < .05$, two-tailed) and from segment 1 to 3 ($t=2.82$, 8 df $p < .05$, two tailed). These findings are shown in Table 2 and graphically depicted in Figures 3 and 4 for females and males respectively.

Table 2

Percent Correct Discrimination Within Three Visual Fields From Segment 1 through Segment 3 for Males and Females and Combined

	Segments								
		1			2			3	
	LVF	CVF	RVF	LVF	CVF	RVF	LVF	CVF	RVF
Males (N=9)	78	73	83	73	73	78	75	73	75
Females (N=9)	75	78	78	70	78	80	75	75	75
Combined (N=18)	76	75	80	72	75	79	75	74	75

Discrimination Peformance and Response Bias - An analysis of the percent correct discrimination scores with each apparent motion situation reveals that for males, females and the two combined, discriminations were better with the 16.09° line as compared to discriminations with the 12.60° line for RVF and LVF with a reversal for CVF. Analysis of responses revealed that the performance differences were due to response bias toward saying "A" (16.09° velocity) in LVF and RVF and "B" (12.60°) in CVF.

Event Related Potentials - The ERP traces of all subjects showed several components from which the latency and amplitude measurements were made.

Latencies - Four components were identified; N2, P2, N3, and P3. The latency component N2 was measured from the peak of a large negative wave appearing between 150 and 175 msec post stimulus in the 500 msec sample. A positive peak immediatedly following N2 and appearing between 200 and 230 msec was termed P2. The latency component, which appeared

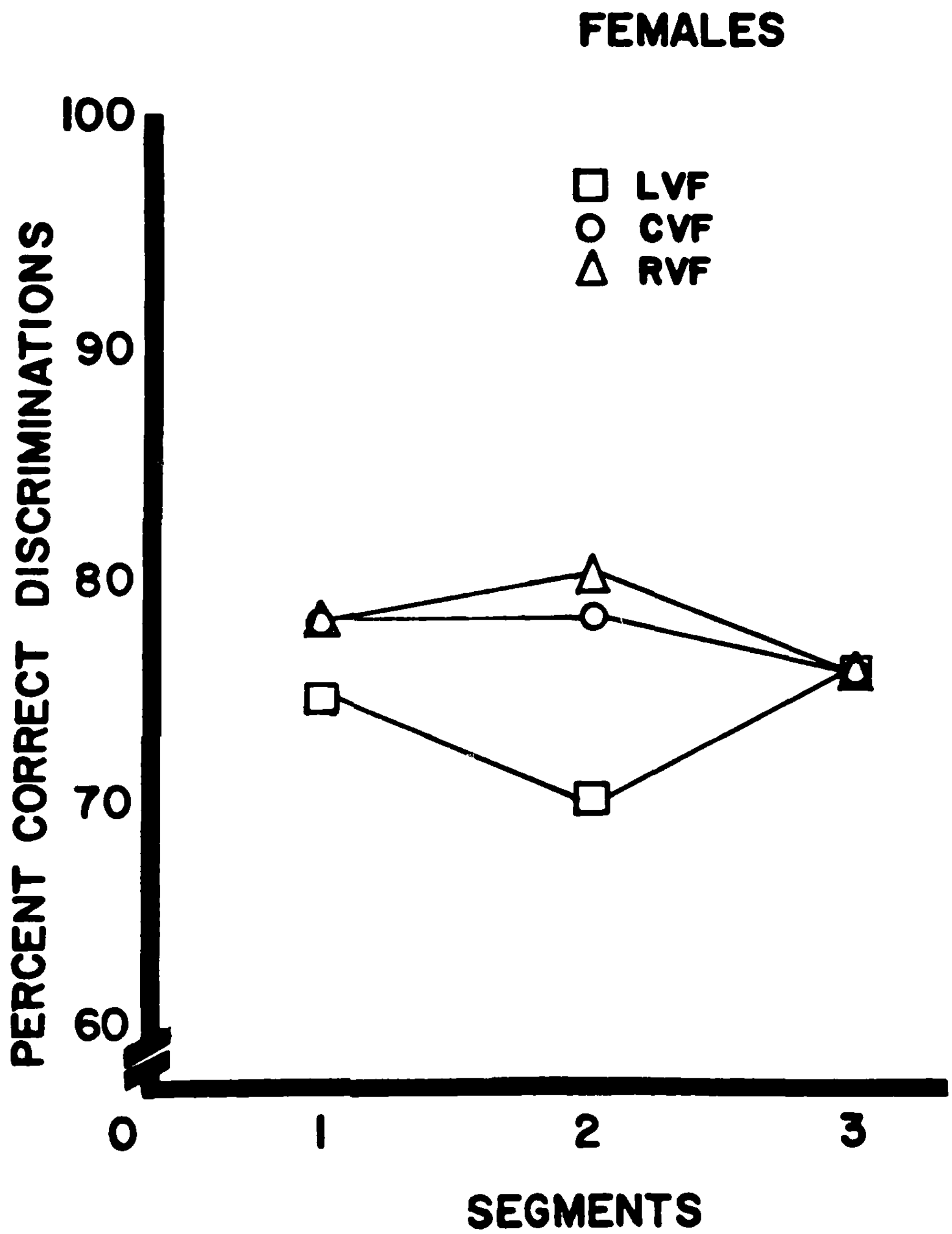

Figure 3 - Percent correct discriminations of the motion velocities combined as a function of time segments (20 minutes from segment 1 to 3) for females.

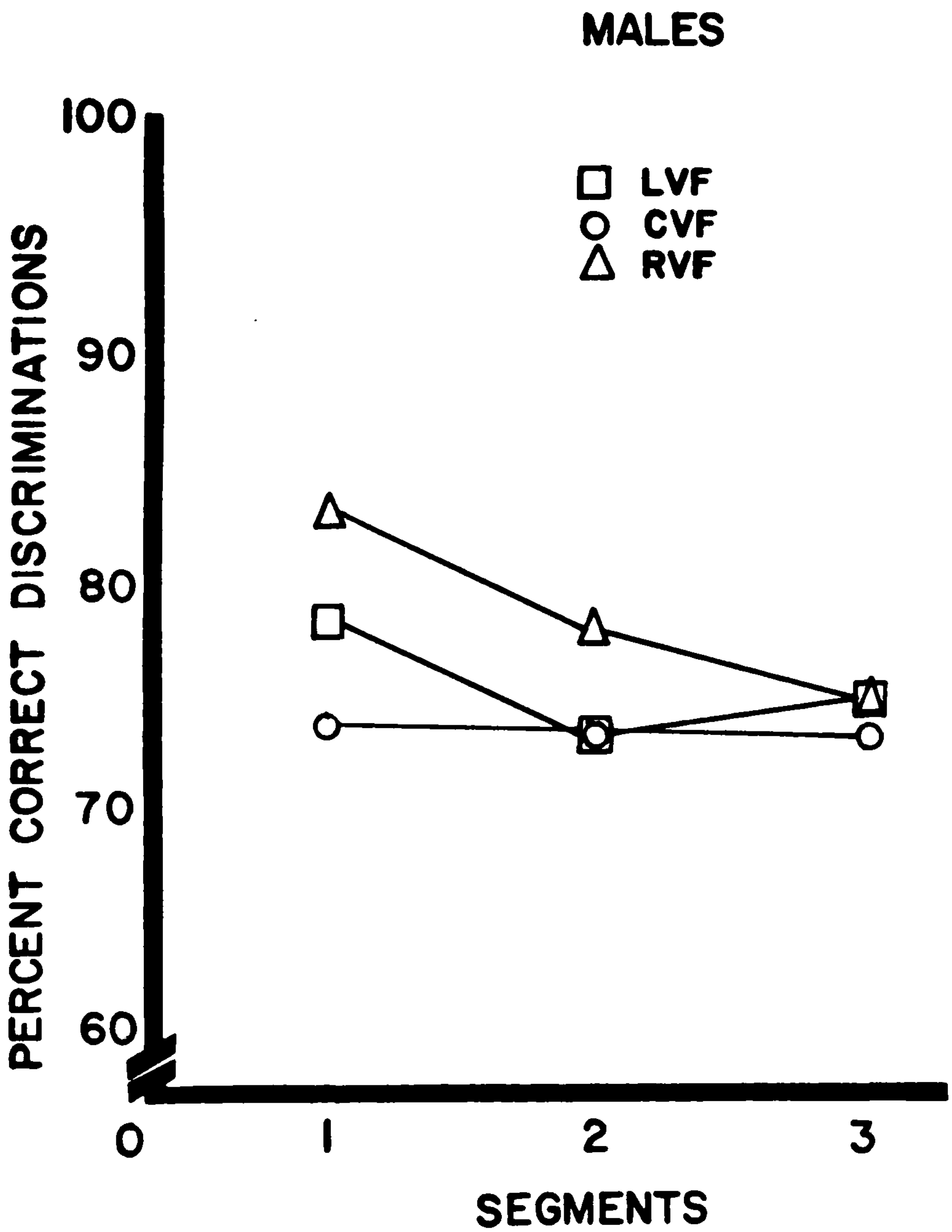

Figure 4 - Percent correct discriminations of the motion velocities combined as a function of time segments (20 minutes from segment 1 to 3) for males.

between 240 and 280 msec was termed N3. The P3 latency component was a second large positive peak occurring between 300 and 380 msec. If the peaks appeared more as a plateau the midpoint of the plateau was taken as the latency measurement.

Amplitudes - Two major components were analyzed with regard to amplitude. These were N2-P2 and N3-P3. For N2-P2, the measurement in microvolts (uV) was taken as the vertical distance from the peak of N2 to the peak of P2. The N3-P3 amplitude component was measured in a similar way, i.e., the vertical distance from N3 to P3. Figures 5 and 6 show the ERP traces of one female and one male subject recorded at both scalp locations under the six experimental conditions. The P3 component is indicated by a small vertical bar.

N2-P2 amplitude - The main statistical test used to analyze this component was a 3-way ANOVA (Gender X Conditions X Placements). The Gender effect was non-significant F=1.92 (1/215) $p > .05$, nor did we obtain significance for the Condition X Placement interaction F=1.66, (5/215), $p > .05$. Separate ANOVAs for males and females revealed a significant Condition X Placement interaction effect for females, but not for males (Males - F=1.42, (8/108) , $p > .05$, Females - F=8.47, (8/108), $p < .01$). Table 3 shows N2-P2 amplitude and N2 latencies for males, females and the two combined. Figures 7 & 8 graphically depict the amplitude data for females and males, respectively.

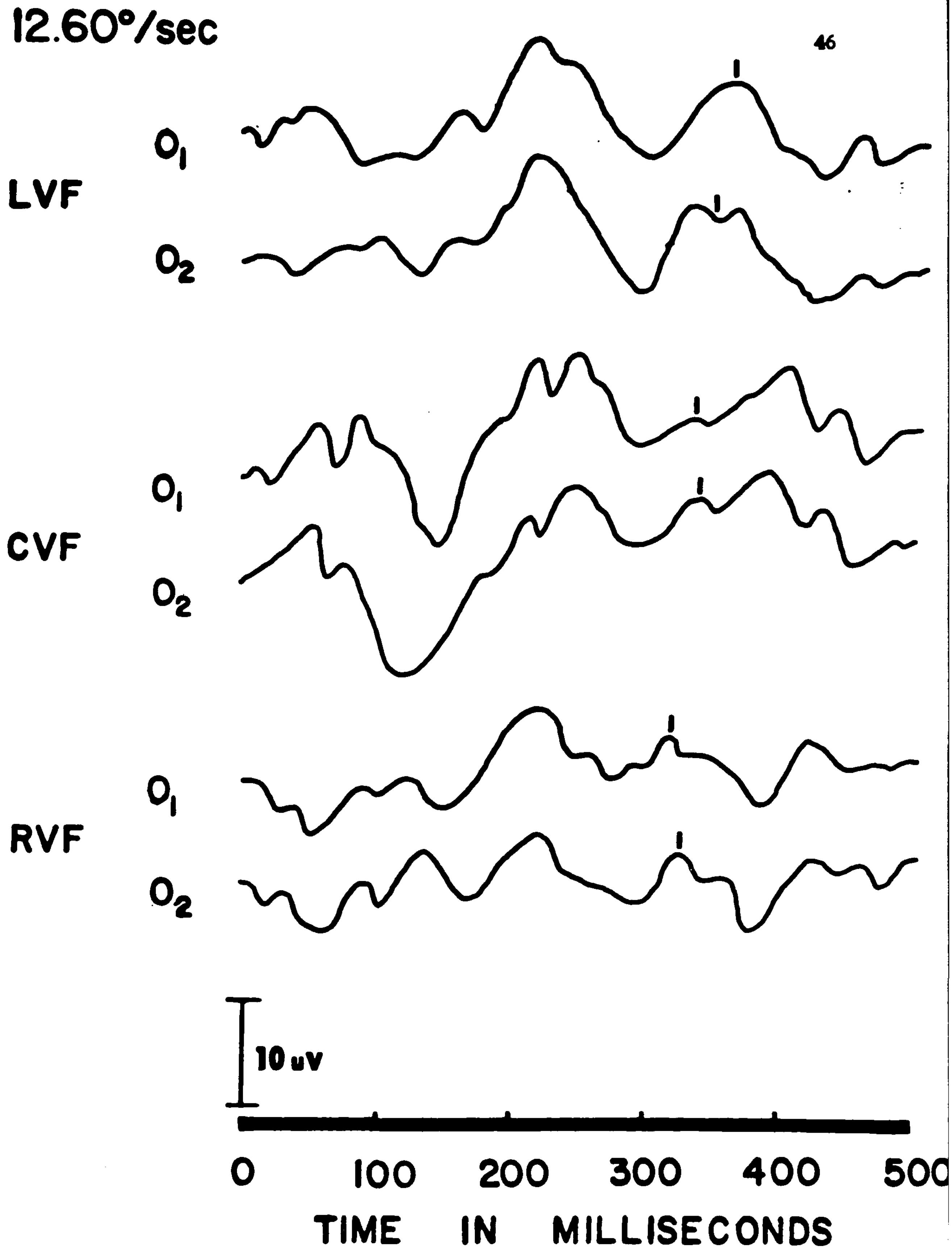

Figure 5 - Visual ERPs of one female subject (A.D.) recorded from O_1 (left hemisphere) and O_2 (right hemisphere) for the 12.60° /sec velocity conditions. The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

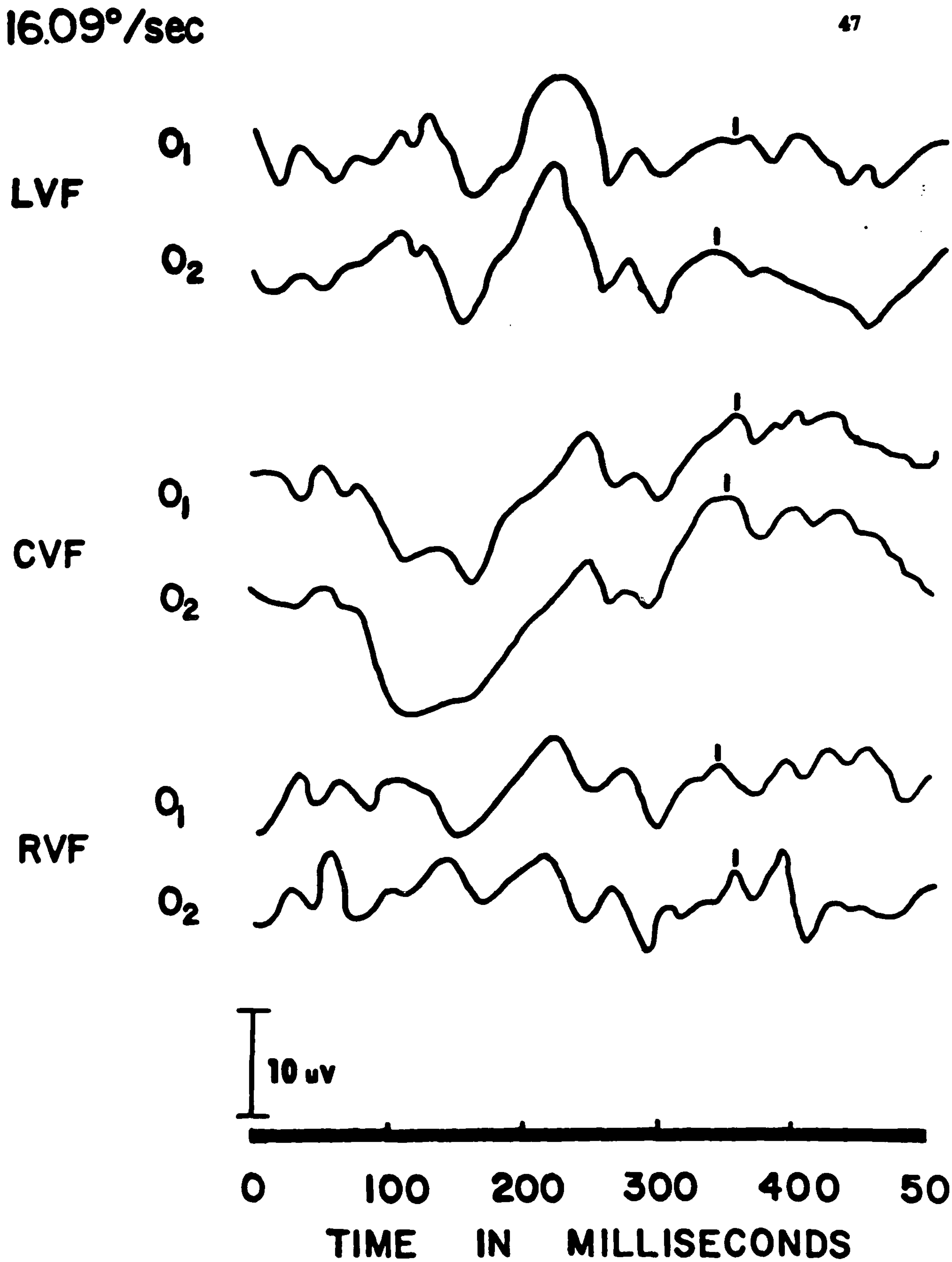

Figure 5 - Visual ERPs of one female subject (A.D.) recorded from O_1 (left hemisphere) and O_2 (right hemisphere) for the 16.09° /sec velocity conditions. The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

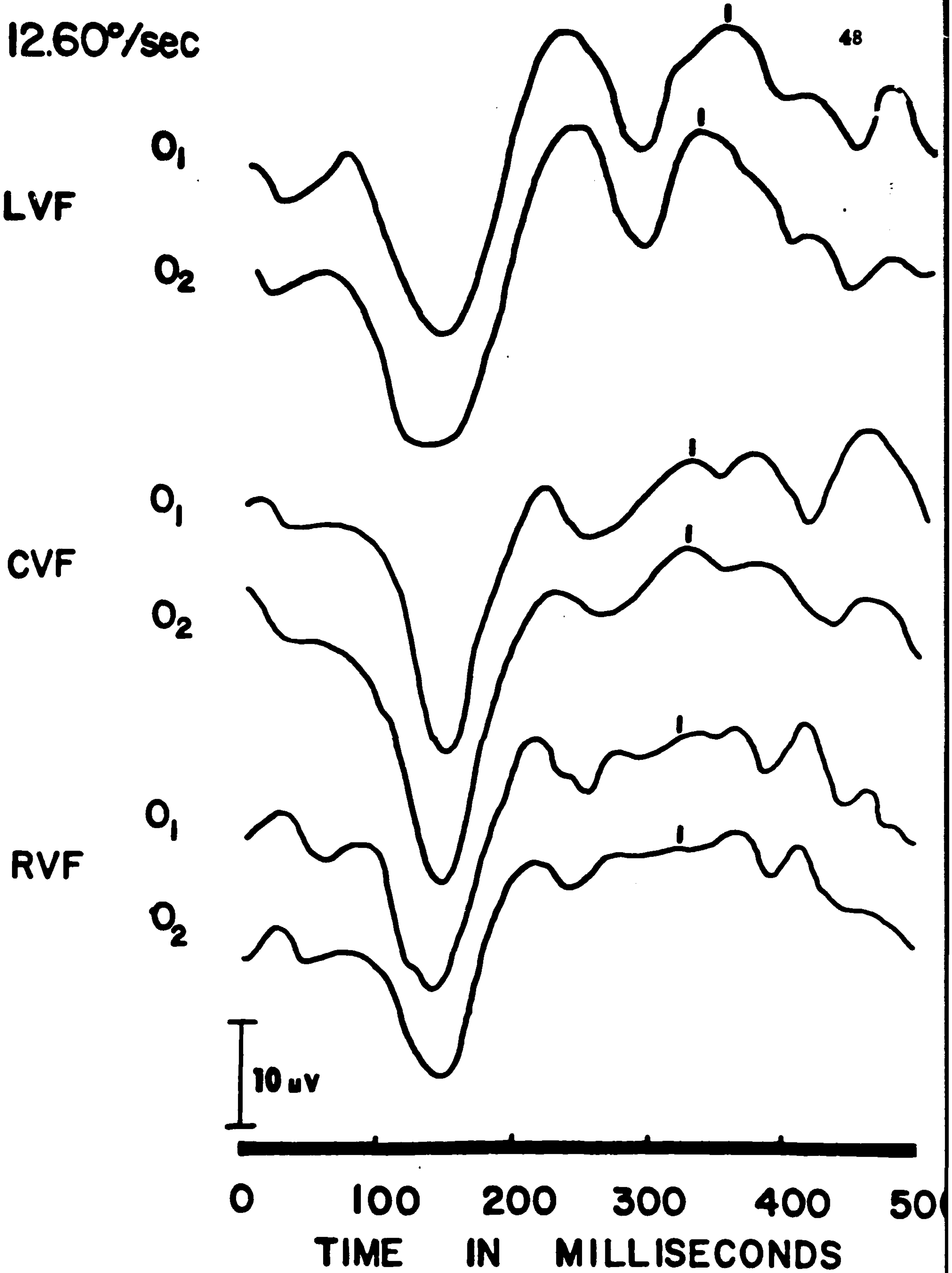

Figure 6 - Visual ERPs of one male subject (A.G.) recorded from O_1 (left hemisphere) and O_2 (right hemisphere) for the 12.60° /sec velocity conditions. The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

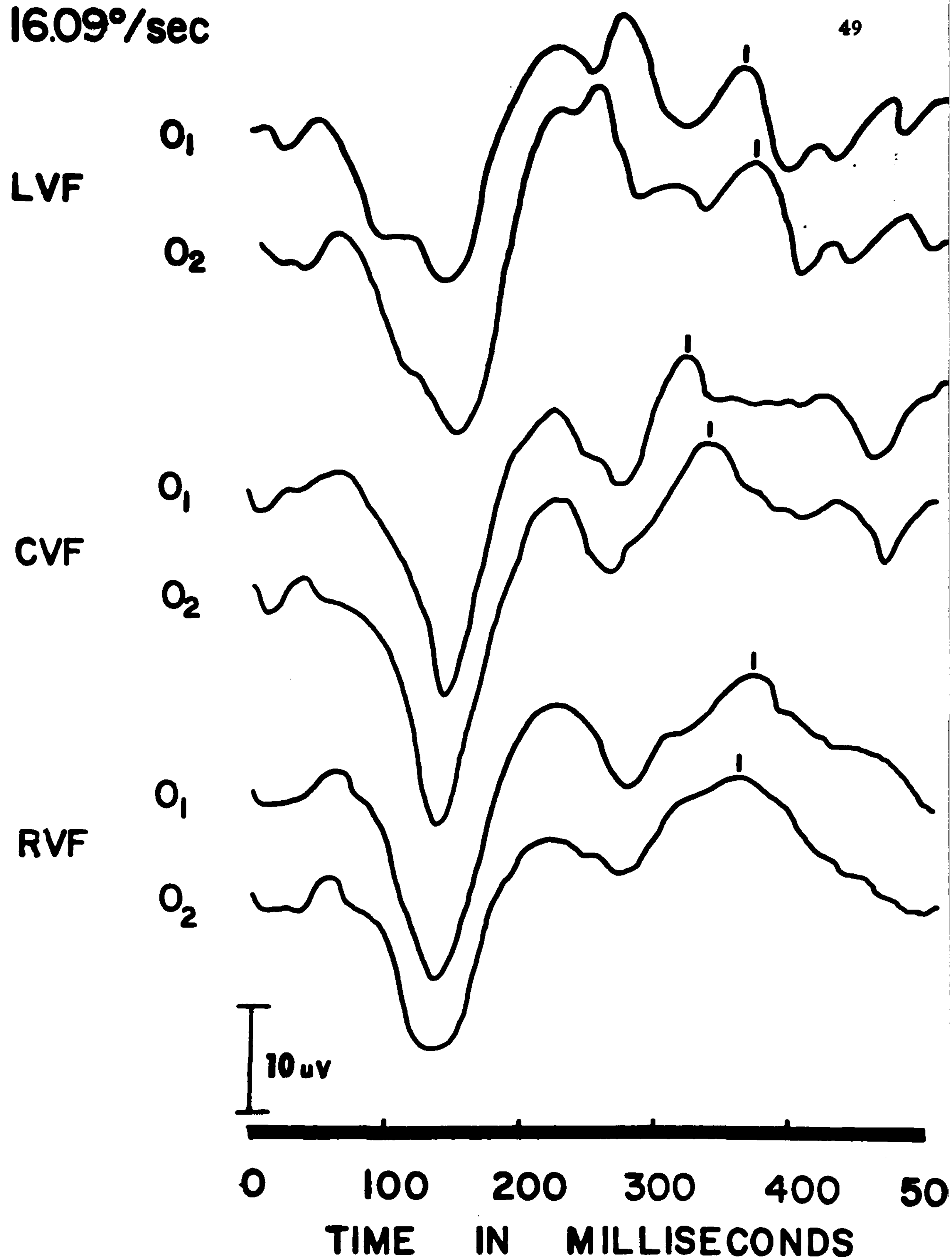

Figure 6 - Visual ERPs of one male subject (A.G.) recorded from O_1 (left hemisphere) and O_2 (right hemisphere) for the 16.09° /sec velocity conditions. The vertical bars indicate P3, i.e., the first positive component occurring between 300 and 400 msec post-stimulus. Negativity is downward.

Table 3

Mean Latency (msec) and Amplitude (uV) for Visual ERP Components N2, and N2-P2 for Males, Females Males and Females Combined for Placements and Conditions

	O_1						O_2					
	(N=6) Males		(N=6) Females		(N=12) Combined		(N=6) Males		(N=6) Females		(N=12) Combined	
	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2	N2	N2-P2
LVF 12.60°	175	17.1	155	17.0	165	17.0	159	19.6	143	19.9	151	19.7
LVF 16.09°	167	16.0	154	17.0	160	16.5	155	18.5	150	21.2	152	19.7
CVF 12.60°	162	19.9	154	21.9	158	20.9	158	19.7	153	22.4	155	21.1
CVF 16.09°	158	19.9	157	21.4	157	20.6	158	19.8	156	20.4	156	20.1
RVF 12.60°	165	19.3	149	20.2	157	19.7	175	18.0	159	13.4	166	15.8
RVF 16.09°	162	17.8	148	20.7	155	19.3	174	16.0	164	15.3	169	15.7

The Newman-Keuls tests conducted on the female data supported the significance of the Condition X Placement interaction effect found for this group. Namely, that females showed expected contralateral field effects as well. For example, there were no significant differences in amplitude at O_1, but at O_2, amplitudes with LVF presentations were significantly larger than those with RVF presentations ($p < .05$.). This test also compared responses to the 12.60° velocity condition with responses to the 16.09° condition within each visual field. The results were non-significant ($p > .05$) and indicated that, for this component, there were no differential responses to the velocity conditions used in this study. Figure 7 graphically represents the data for the females.

The amplitude data for males and the combined groups data suggest a

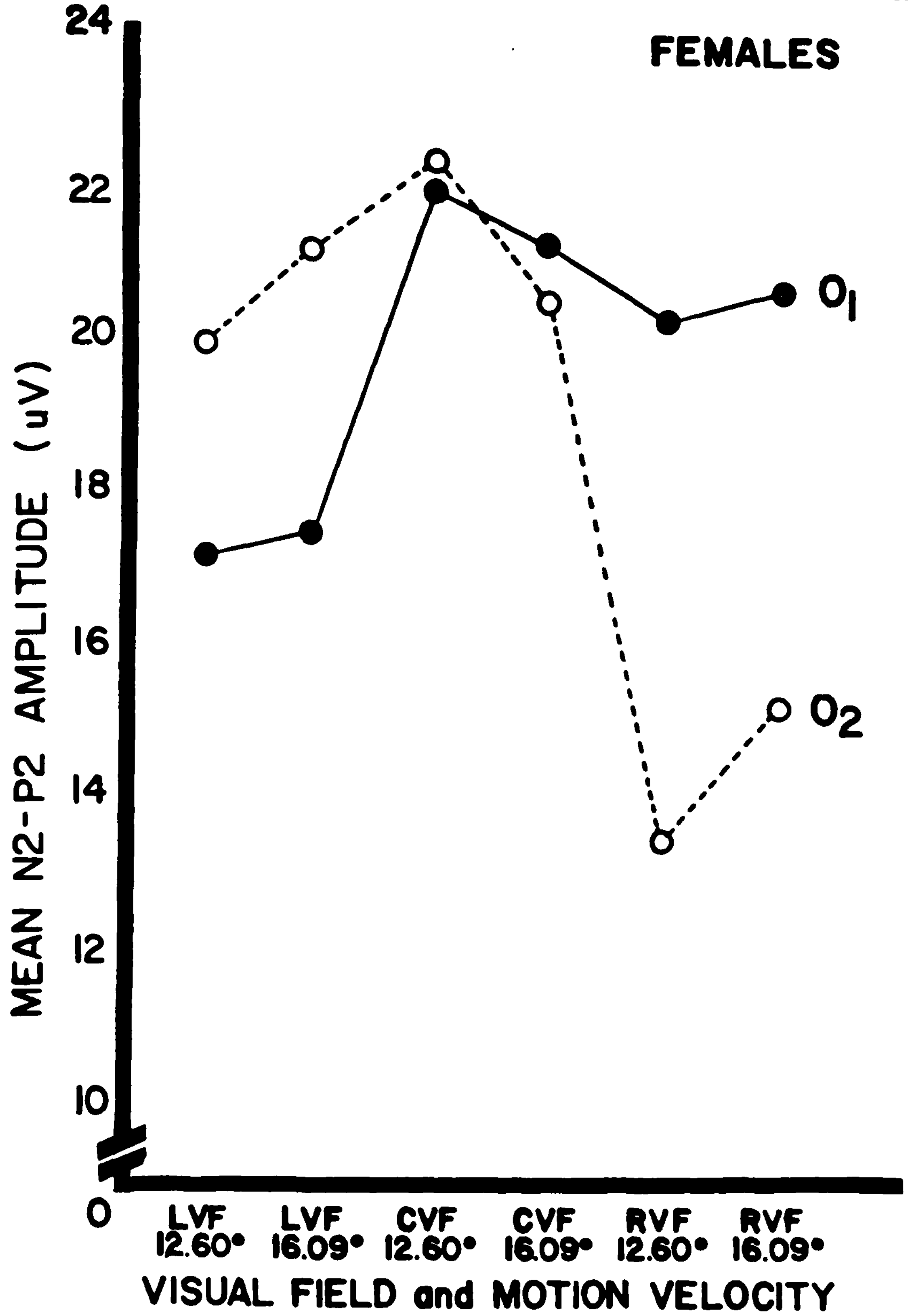

Figure 7 - Mean amplitude of the N2-P2 component of the visual ERP as recorded from O_1 and O_2 for females (N=9).

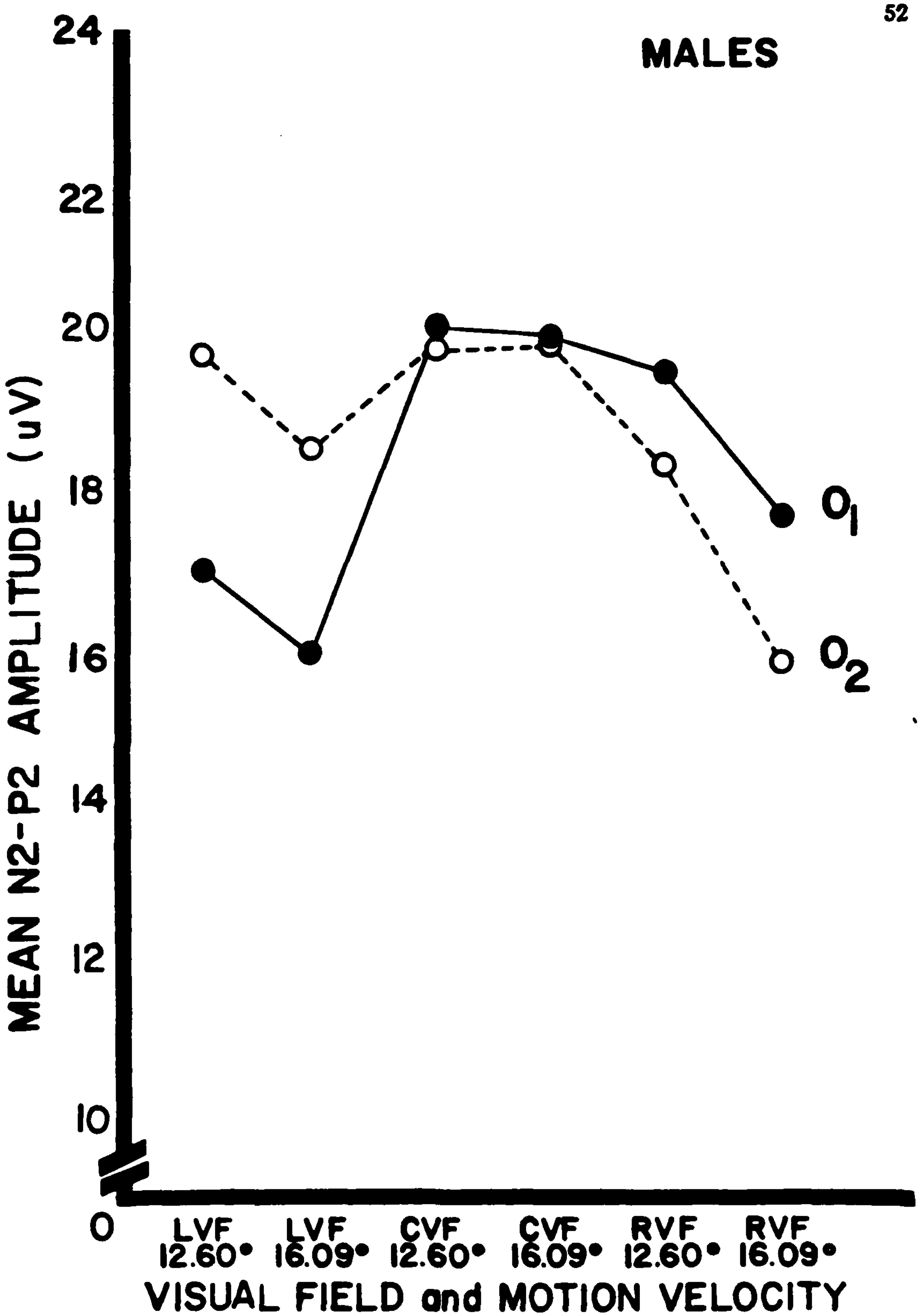

Figure 8 - Mean amplitude of the N2-P2 component of the visual ERP as recorded from O_1 and O_2 for males (N=9).

trend in which amplitudes are largest at the hemisphere receiving direct stimulation, i.e., left hemisphere (O_1) amplitudes were larger than right (O_2) when the stimuli were presented in the right visual field. The opposite occurred for left visual field presentations, i.e., larger O_2 responses as compared to O_1.

The figure depicting the data for females (Figure 7) shows that left (O_1) and right hemisphere (O_2) amplitudes were virtually the same under the 12.60°/sec CVF condition. In addition, left hemisphere amplitudes were larger than right with the 16.09°/sec CVF condition. Thus, the expectation that females would produce larger right hemisphere responses than left to motion stimuli presented centrally was not confirmed. The N2-P2 amplitude data for males also show no O_1-O_2 differences with both CVF situations. However, under CVF conditions and at both scalp locations, females produced larger N2-P2 amplitudes than did males and this can be clearly seen in Figures 9 and 10. The t-tests (uncorrelated data) that examined this hemisphere response advantage for females were found to be non-significant ($p > .05$)

<u>N2 latency</u> - The combined ANOVA on N2 latency (Gender X Condition X Placement) showed a significant Gender effect ($F=25.86$ $(1/215)$ $p < .05$) and reflects the facts that females had shorter N2 latency responses than males. The ANOVA also showed a significant Condition X Placement interaction, $F=3.73$ $(5/215)$ $p < .01$. Separate 3-way ANOVAs for males and females supported the above finding as well i.e., significant Condition X Placement interaction effects (Males - $F=6.00$ $(5/108)$ $p <$ $.01$; Females - $F=13.33$, ($5/108$ $p < .01$). The N2 latency data are shown

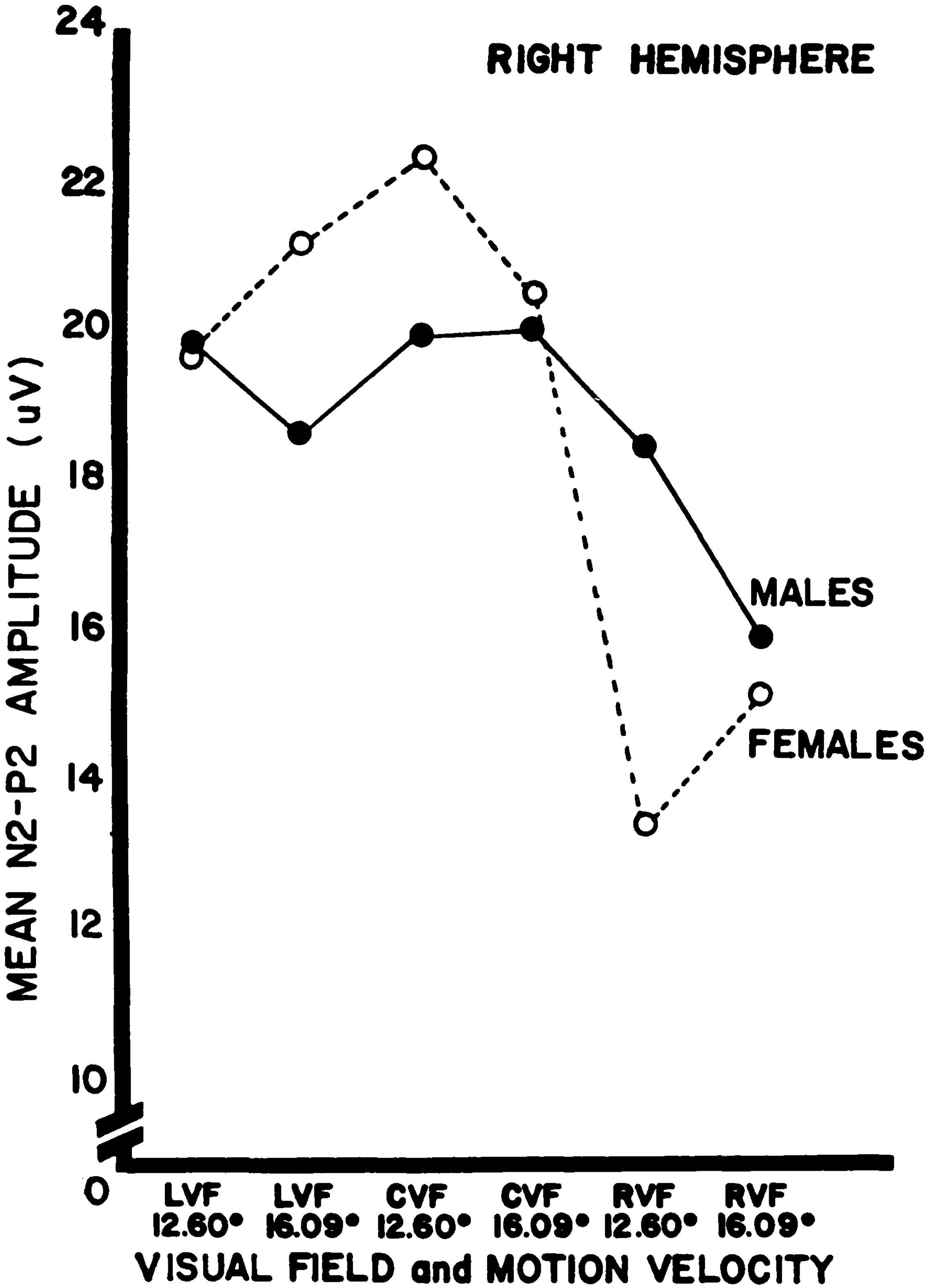

Figure 9 - Mean amplitude of the N2-P2 component of the visual ERP as recorded from O_2 (right hemisphere) for males and females.

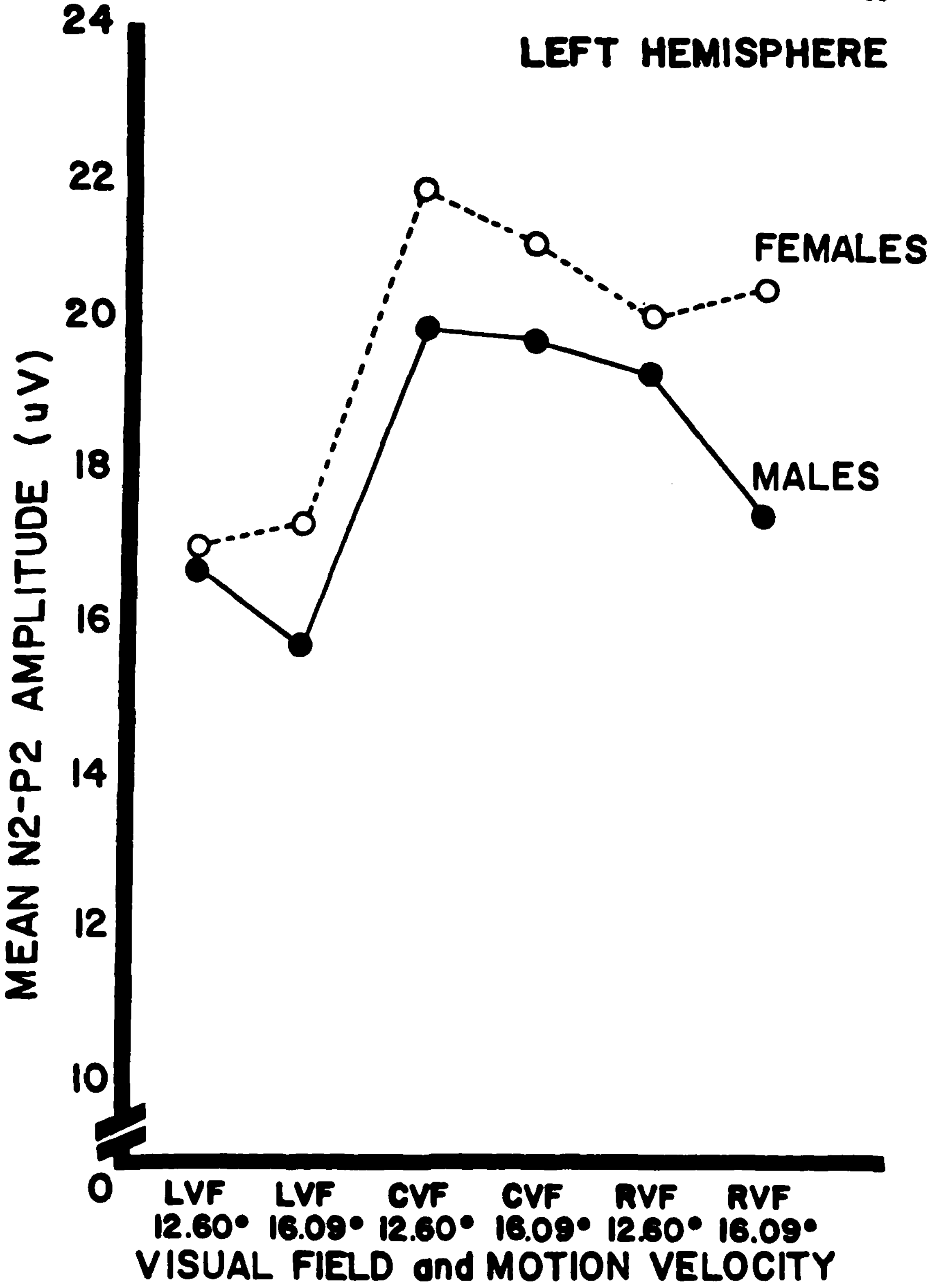

Figure 10 - Mean amplitude of the N2-P2 component of the visual ERP as recorded from O_1 (left hemisphere) for males and females.

in Table 3 and graphically depicted in Figures 11 and 12 for females and males. From the table and the figures it is apparent that N2 latencies were shorter at the recording site contralateral to the field of presentation. Further, Newman-Keuls testing examined these effects for the three groups. The results highlighted the response advantage that occurs at the hemisphere receiving direct stimuluation. For example, with LVF presentations latencies were shorter at the right hemisphere (with $p < .01$ for males females and combined), while the opposite occurred for RVF presentations i.e. shorter latencies at the left hemisphere ($p < .01$ for all three groups). When the multiple comparison tests were used to compare latencies between the 12.60 and 16.09° motion conditions within the three visual fields. There were no significant differences for either males females or the two combined ($p > .05$).

An examination of N2 latency differences with CVF stimulation for O_1 vs O_2 for males reveals that under the 12.60° velocity condition, left hemisphere response was on the average 5 msec longer than right. A t-test for correlated data indicated that this difference was non significant ($p > .05$)

P2 latency - The only significant finding for this component was obtained in the 3-way ANOVA which examined possible Gender differences (Gender X Condition X Placement). For Gender it was 17.27 (1/215), $p < .01$. Similar to the findings on N2 latency, females had shorter P2 latencies than males.

N3-P3 amplitude - A 3-way ANOVA (Gender X Condition X Placement) revealed that both males and females had larger N3-P3 amplitudes with

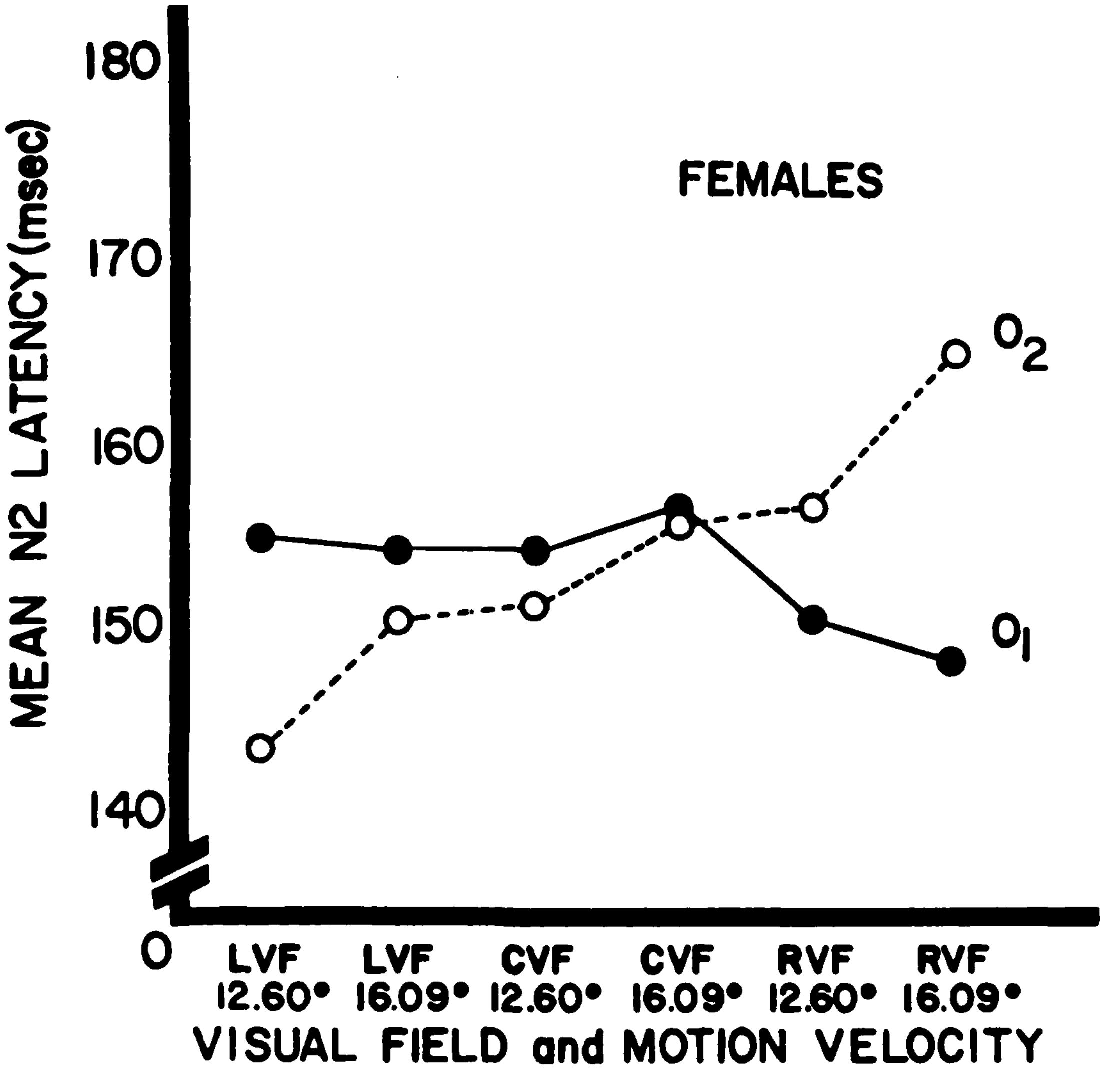

Figure 11 - Mean latency of N2 component of visual ERP as recorded from O_1 and O_2 for females (N=9).

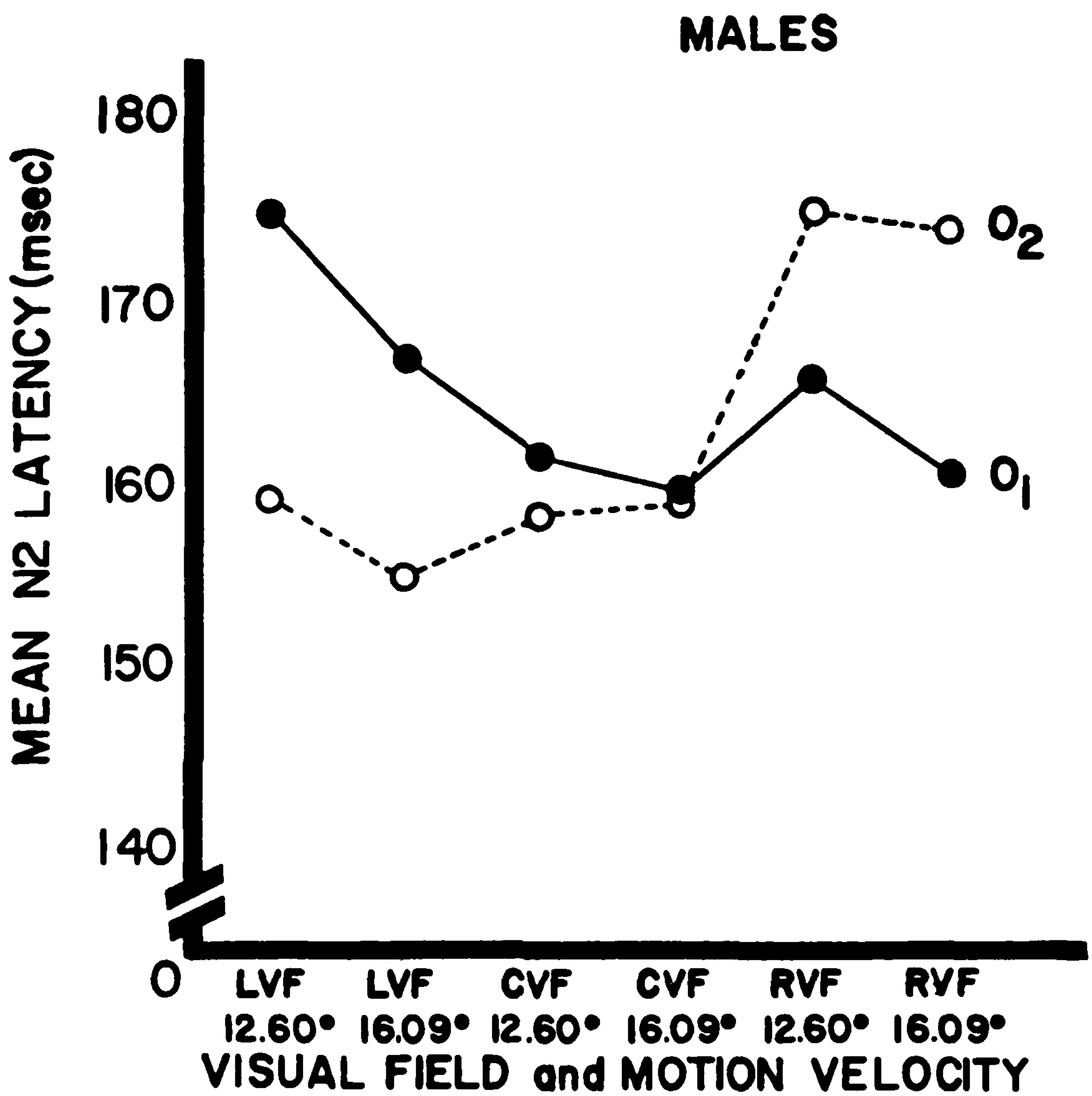

Figure 12 - Mean latency of N2 component of visual ERP as recorded from O_1 and O_2 for males (N=9).

the 16.09° line than with the 12.60° line, but only within the right hemisphere recording site (O_2). This finding can be seen in Table 4 below. There appears to be no differential response between the motion velocity conditions within the left hemisphere site. This led us to consider additional statistical tests to determine if this right hemisphere trend was significant. The amplitude data for the 12.60°

Table 4

Mean Latency (msec) and Amplitude (uV) of the Visual ERP Component N3-P3 of Males, Females, and Males and Females Combined, for Placements and Conditions

	O_1						O_2					
	Males		Females		Combined		Males		Females		Combined	
	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP	P3 LAT	N3-P3 AMP
LVF 12.60°	350	12.8	352	11.1	359	11.9	343	11.5	354	10.4	349	10.9
LVF 16.09°	352	12.8	342	11.5	347	12.1	346	12.7	341	11.4	344	12.0
CVF 12.60°	355	13.0	363	9.4	359	11.5	353	12.1	363	8.9	358	10.5
CVF 16.09°	347	13.5	355	11.1	351	12.3	348	14.0	352	11.1	350	12.6
RVF 12.60°	345	13.4	350	10.9	348	12.1	347	13.2	349	9.9	348	11.5
RVF 16.09°	340	15.7	346	11.1	343	13.4	341	15.3	346	13.2	344	14.3

condition within each visual field were combined to allow for direct response comparisons between the two velocity conditions within each scalp location (i.e., LVF 12.60° + CVF 12.60° + RVF 12.60°/3 vs LVF 16.09° + CVF 16.09° + RVF 16.09°/3 - O_1 and O_2 separately). The data were then subjected to t-tests for correlated data. The t-test results for the right hemisphere response comparison indicated that N3-P3 amplitudes were significantly larger with the 16.09° line than

responses with the slower (12.60°) line, $t=2.60$, 17 df $p < .05$, two tailed. The same amplitude comparisons within the left hemisphere were non-significant ($p > .05$). This was due to the fact that 5 of the 18 subjects had reversals, i.e., larger N3-P3 amplitudes with the 12.60° line. Separate tests on males and females for the same comparisons were also non-significant. Thus, right hemisphere derived N3-P3 amplitudes showed differential response to the two velocity conditions while the left hemisphere did not. Males and females did not differ in response to the two velocities.

P3 latency - A 3-way ANOVA was conducted to examine the possibility that P3 latencies would show differential responses to the motion conditions. The computed F-ratio failed to reach significance $F=1.36$, (5/215) $p > .05$. Moreover there were no significant differences between males and females $F < 1$. The P3 latencies for males, females and the two groups combined are shown in Table 4 along with the N3-P3 amplitude data.

Discussion

Were right hemisphere discriminations of motion velocity superior to those under left hemisphere control? The performance data concerning discriminations of the motion velocity conditions used in this study indicate that this was not the case. In fact, left hemisphere discriminations were found to be superior to the right. Thus, these preliminary results suggest that motion velocity may be more efficiently processed in the left hemisphere when data from all

18 subjects are considered. A separate analysis of male-female performance indicated that females contributed to this effect more than males. At first glance one might consider motion perception to be a right hemisphere task since it involves changes in spatial location. However, it could be that the temporal nature of the stimulus situation prevails, thus making it a sequential-temporal activity, or a type of activity considered to be the domain of the left hemisphere. This suggestion is plausible when one considers the "sequential" or "temporal" characteristics required to produce apparent motion of different velocities and the fact that other investigators have provided evidence that tasks involving sequential tactuo-motor and temporal processing are under control of the left hemisphere (e.g., Provins 1958; Carmon, 1978, respectively). In addition, this type of processing may be more highly developed in the left hemisphere of females as compared to males (Biersner, 1980). One also notes that unlike other visuo-spatial tasks in which males have been found to excel (see McGlone, 1980) the female subjects in the current study performed as well as males. Efficient perception and processing of moving stimuli would favor both male and female survival, and from an evolutionary perspective, would be highly adaptive. A recent study reported in Science (October 29, 1982) demonstrated that human infants exhibit a preference for light patterns which describe biological motion, supporting the possibility that the perception of this type of motion is an intrinsic capacity of the visual system. Thus, there is some evidence that perception of

motion is a very basic capacity, not dependent on experience.

Another finding was that the left hemisphere showed performance decrement over time, for male subjects. The right hemisphere showed little decrement in that it started at a slightly lower level of performance than the left and stayed there throughout the 20 minute period. These findings are similar to those of Dimond and Beaumont (1973) who presented signals in the left and right visual fields during an 80 minute vigilance task. These investigators found that subjects who had left hemisphere presentations showed superior detection performance which decreased over time. Little decrement was seen in the right hemisphere group in which performance started and remained at a lower level. It is our intention to do a follow-up study to determine whether this observed decrement in velocity discrimination for male subjects is reliable over a longer time frame.

The hypothesis that ERP amplitudes would be larger from right hemisphere derivations for females with CVF presentations was not supported. In fact, our female subjects, like males, showed no differential hemispheric response with the two velocities. The reason for this may lie in the differences in methodology between the Andreassi and Juszczak (1982) study and this experiment. For example, in the earlier investigation, subjects simply observed and counted the motion presentations, while in this study they were required to make discriminations between two different velocities and to verbally report their discriminations. This may have induced our female subjects to adopt a different attentional strategy than the one used

in the "passive" observation situation. Another change involved the direction of motion used. Namely, we used vertical (up-down) as opposed to horizontal (left-right) motion in the earlier study. While in both studies, the perception was that of a single moving line, the change in direction of the motion in this study may have provided a completely different perceptual situation for our subjects.

Laterality effects were found with the endogenous P3 component. Namely, larger P3 amplitudes were found with the faster velocity situation as compared to responses with the slower one, but only at the right hemisphere. Is the right hemisphere more cognitively involved in analyzing the faster motion situation? Perhaps, but it should be cautioned that any such suggestion would be highly speculative at this time and that the findings require replication.

The fact that the earlier components, N2 and P2 (latency), N2-P2 (amplitude) showed contralateral visual field effects, and the P3 did not, indicates that they are stimulus bound while the later P3, is related to cognition. We found, too, that females produced significantly shorter N2 and P2 latencies than males; a finding that was observed in an earlier investigation (Andreassi and Juszczak, 1982). The tentative explanation offered for this finding was that the female brain is on the average smaller than the male brain and, therefore, neuronal transmission time may be faster.

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